PRODUCT ENGINEERING

DEVOTED TO THE INTERESTS OF ENGINEERS AND EXECUTIVES RESPONSIBLE FOR PRODUCT DESIGN AND DEVELOPMENT

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PRODUCT ENGINEERING

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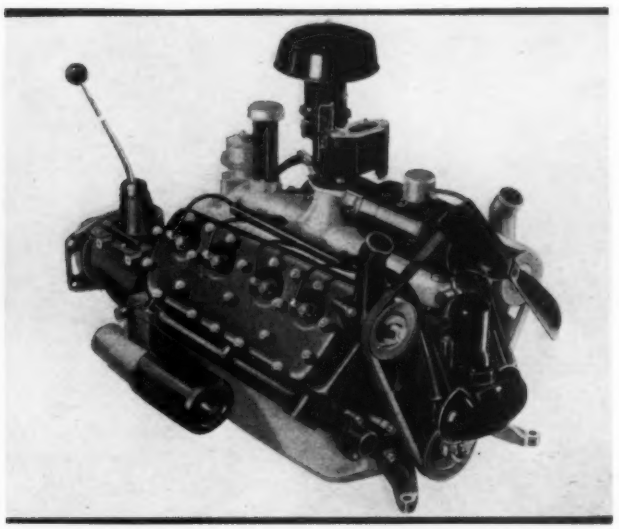


Analyzing the Design of the FORD V-8 ENGINE

GEORGE F. NORDENHOLT

Associate Editor

SPEAKING before a group of automobile dealers representing many makes of cars, the vice-president of one of the leading automobile manufacturers said: "I want you fellows to know how the boys back in the factories have been working their heads off, burning the midnight oil, to give you fellows the biggest automobile value you have ever had the chance to sell. I want you to know how the engineers have been toiling days, weeks and months with only one thought in mind, and that was to make possible the production of a car incorporating all of the refinements of the arts and science and industry, and yet one that would shock the public into buying by making them realize that in so far as the automobile dollar is concerned, their salaries have been raised."

First it was rumored, then gossiped about. Finally it was heralded to an anxious world. Here are the results of a study of the details of this remarkable engineering accomplishment

Every engineer who has in any way interested himself in the latest offerings of automobile manufacturers, realizes the truth of the statement that automobile designers have done remarkable work. The latest public offering is the 8-cylinder Ford car. Its general description is well known. But behind this finished product lies a story of engineering ingenuity and courageous design. The "how and why" of the Ford engine, as revealed by an engineering analysis of this remarkable product, is the story of "toiling days, weeks and months with only one thought in mind."

In studying the Ford engine, it appears that there are two fundamental principles followed in its mechanical layout with the object of producing the lightest and most compact engine possible.

1. Wherever possible, connecting machine elements are eliminated. This is illustrated in the omission of valve push rods, the direct drive of the fuel pump off of the camshaft, and the single V-belt drive serving the two water pumps, the fan and the generator.

2. When possible, one piece serves

several purposes. Thus the valve chamber cover plate serves also as the intake manifold, and the cylinder block casting is extended at its rear end to include the flywheel housing.

The design of the Ford 8-cylinder, 90-deg. V-engine hinges around the cylinder block. Herein the engineers immediately depart from all the customary methods of cylinder block construction. As shown in the accompanying longitudinal section, cylinder block and crankcase, together with the flywheel housing, are all in one piece. This eliminates many bolts and their accompanying bosses, saving that much room for other purposes. Furthermore, it is superior construction in that it gives a definite relative position to the crankshaft bearings that can not be altered because of improper alignment of connected members. And, of course, there is also to be considered the saving in weight and space.

Along the same engineering principles, the valve chamber is located on the inner side, this being the most accessible place to get at the valves. A thin wall separates the bottom of the valve chamber from the crankcase. The next step is to furnish a cover for the valve chamber.

Here again is shown remarkable engineering ingenuity. The intake valve ports are on the top horizontal surface of the cylinder block, toward the inner side. What can be more simple than to design a cover plate with cored passages to serve as the intake manifold? And then to complete the idea, the down draft carburetor is mounted directly on top of the center of this combination cover plate and manifold. Even that by no means completes the number of purposes this cover plate serves.

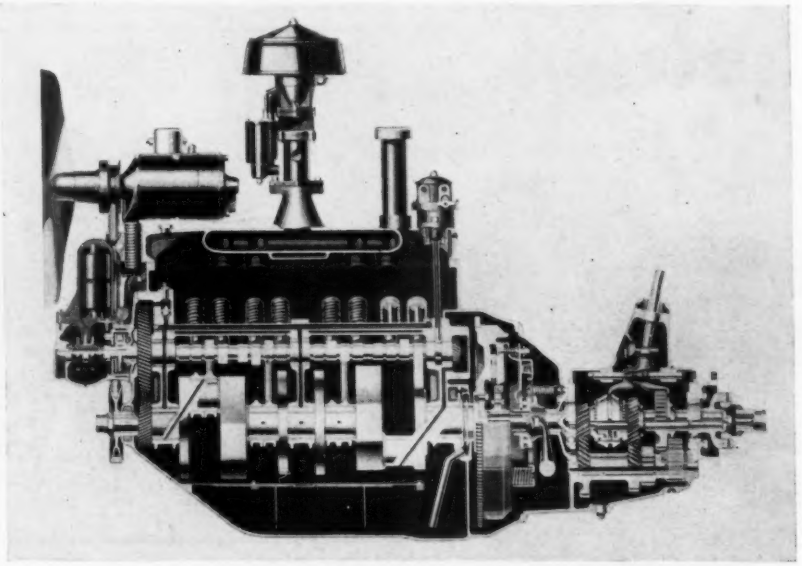
It is necessary to provide a filling point for the crankcase oil. Therefore, holes are put in the wall between the crankcase and the valve chamber. The oil-filler pipe is then screwed into the cover plate. Directly behind the oil filler is mounted the fuel pump, directly driven from the camshaft. This location of the fuel pump gives a short direct connection to the carbureter. Thus we see how this cast-aluminum cover plate, which is usually merely a steel sheet, is designed to serve several purposes.

The fuel pump construction is interesting. Between the upper and lower die-castings that comprise the body, this fuel pump has clamped around its edge a flexible membrane consisting of four layers of thin tough material. At its center, this membrane is clamped between two disks, these disks being on the end of a connecting rod that is driven by an eccentric on the camshaft. This construction can be seen in the sectioned view of the engine. In the upper chamber of the fuel pump are located the valves which are simply pieces of molded composition held over the valve port by means of a spring. The fuel enters through a vertical standpipe in the center of the upper die-casting and discharges into the space directly below the stamped cover. Between the cover and the upper die-casting is a thin copper gauze for straining out any foreign matter.

In carrying out the idea of designing as short an engine as possible, the Ford engineers undoubtedly hit what might have appeared at first as a serious obstacle. The length of the connecting rod bearing usually establishes minimum cylinder spacing. But the length of the bearing is dictated by the allowable unit bearing pressure.

Here the Ford engineers showed remarkable ingenuity. The total relative motion between the connecting rod and crankpin is composed of two elements: One is the rotation of the crank. The other is the angular motion of the connecting rod. But the latter's speed is small compared to the crankpin bearing speed. Furthermore, the bearing surface velocity at the connecting rod goes to zero twice each revolution and is reversed. All of these factors are exceptionally favorable to permit higher bearing pressures on the connecting rod. Evidently, if the connecting rod bearings were separated from the crankpin and the separating member were to serve two rods, it would be possible to use relatively short rod bearings. This is exactly what was done. The result represents an entirely new design in such engine construction.

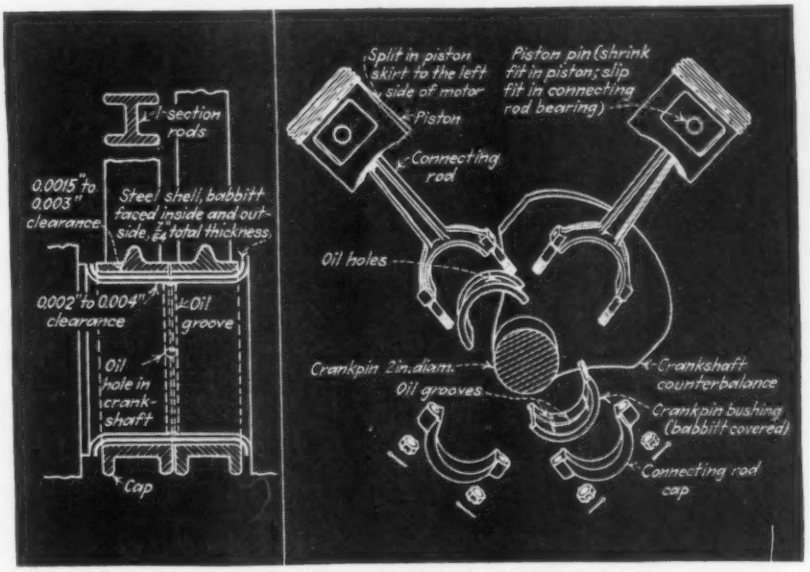
In the accompanying diagram is shown the construction of the connecting-rod crankpin bearings. A steel liner babbitted inside and outside extends the full length of the crankpin and serves two rods. The pressure from each rod is thereby distributed over almost the whole length of the crankpin, and as maximum pressures do not occur in both rods at the same time, the varying pressure is averaged. Lubrication is through a hole in the center of the crankpin which leads the oil into the circum-



This longitudinal view shows how the Ford engineers succeeded in producing a remarkably compact 8-cylinder engine. On top of the cast aluminum combined coverplate and intake manifold are mounted the fan, generator, down-draft carbureter with air cleaner, oil filler pipe, and diaphragm fuel pump

ferential groove in the center of the liner. Thus, for the two rods there are only two points of lubricant end-leakage at the crankpin bearings, another favorable factor.

In such a design, it would be impossible to use shims because any take-up in clearance on one bearing would correspondingly increase the clearance on the other bearing. Hence, the rods, crankpins and bearing inserts are all machined to exact limits so that the desired clearances will be obtained. Experience has shown that the wear on the bearings is extremely slow. When it has eventually become excessive, the inserts are simply replaced. To compensate for wear on the rods and crankpins, slightly thicker inserts will be used.


I-section rods
0.0015" to 0.003" clearance
Steel shell, babbitt faced inside and outside, 1/4 total thickness
0.002" to 0.004" clearance
Oil groove
Oil hole in crankshaft
Cap
Split in piston skirt to the left side of motor
Piston pin (shrink fit in piston; slip fit in connecting rod bearing)
Piston
Connecting rod
Oil holes
Crankpin 2in. diam.
Oil grooves
Crankshaft counterbalance
Crankpin bushing (babbitt covered)
Connecting rod cap

This unusual construction of the connecting rod bearings effected a saving in the length of the crankpins, making possible close longitudinal spacing of the cylinders, hence a short cylinder block and a short rigid crankshaft. To the left is shown an enlarged longitudinal section of the bearing assembly

It is interesting to note that in the design as originally made, the main bearings were of standard construction and did not use inserts. However, the successful performance of the crank bearings made the engineers decide to use inserts for the main bearings also.

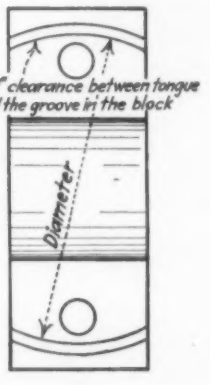
The most important result of this ingenious crankpin bearing construction is the shortening of the cylinder block and crankshaft. Both of these have far reaching effect. The short block makes it more feasible to add the flywheel housing at the rear end without getting into an unwieldy or impractical casting. The advantage gained here includes the elimination of a separate bolted-on housing with all its attendant machined fitting surface, bolts, assembly labor, and alignment problem. As for the short crankshaft, it is both light and rigid.

As mentioned briefly, the conventional crankcase is designed to be cast integral with the cylinder block. The savings in machining and assembly costs are self-evident. Also, the main bearings can then be bored to assure their exact alignment and relation to the cylinders. Here again, Ford engineers add another refinement in bearing design that, to the writer's knowledge, has never been used before.

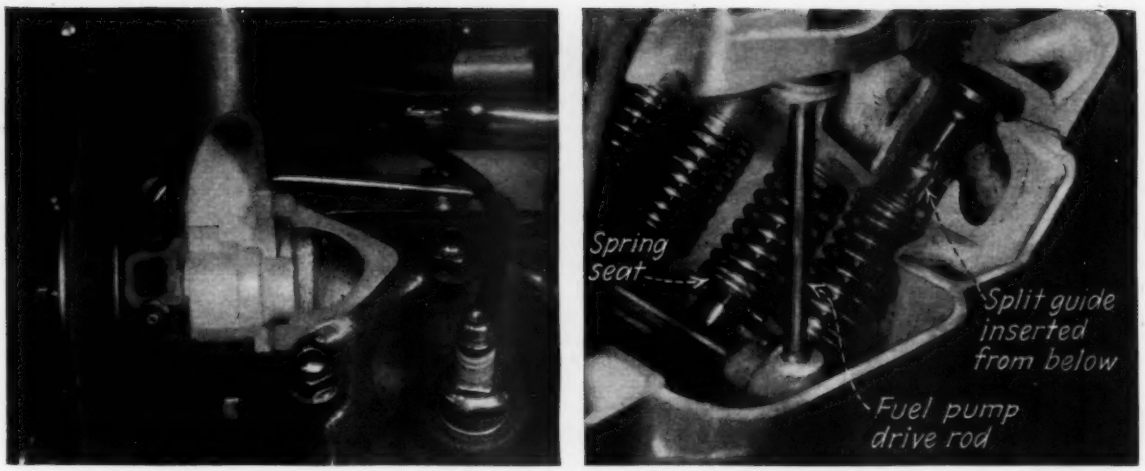
In order that the main bearing cap bolts may not be subjected to shear resulting from the thrust on the crankshaft, the engineers provide a tongue at each end of the bearing cap to fit into mating grooves in the cylinder block. The usual practice is to make such tongues parallel to the axis of the bearing. This, however, makes it necessary that both the tongue and groove be machined with great accuracy, and the accuracy carried through to the bearing inserts. To solve this vexing problem, they simply make the tongues and grooves in the shape of arcs of a circle whose center coincides with the center of the bearing. Thus, in assembly the caps will align themselves with the crankshaft, thereby assuring a perfect fit. Simple as it is, it would be interesting to know how much "midnight oil" was spent before this idea was hit upon.

It has always been the custom to have valve push rods interposed between the valve stem and the cam so as to permit adjustment of the valves. Bearing in mind the slogan to eliminate unessential parts, the Ford engineers evidently undertook to do away with the push rods, and succeeded. When analyzed completely, there is only one legitimate reason for push rods: namely, adjustment. But is such flexible adjustment really necessary? Yes, but, with rare exceptions, only when the valves have been ground, and in every instance the adjustment is to effect a shortening of the stem and rod. Therefore, why not include in the valve grinding operation a grinding operation wherein, for valve adjustment, the proper amount will be ground off the bottom of the valve stem?

In the accompanying illustrations is shown a cut-away view of the simple valve construction. The design can best be described by the method used in assembling the valve. The valve spring is held compressed in a special tool. The valve is slipped bottom end first through the machined hole in the cylinder block and through the compressed spring. A split valve guide is then put around the stem and slid up into its machined seat in the cylinder block. A spring seat is placed directly on top of the enlarged diameter portion of the lower end of the rod. The spring is then released, and bears on the spring seat at its



The circular tongue at each end of the bearing cap fits into grooves in the cylinder block



Left—The pump for circulating cooling water is extremely simple—the cast impeller requiring no machine work other than boring. Right—Cut-away section at right rear end of cylinder block showing valve assembly

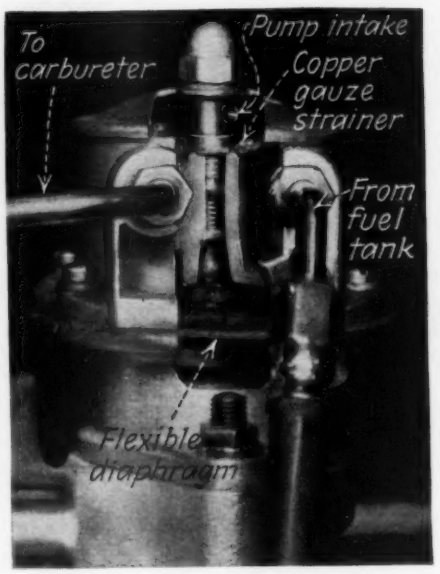
lower end and the split-guide at the upper end, holding the latter in position.

The camshaft is located above the crankshaft. Near its rear end it drives the fuel pump; at its front end it drives the distributor. A helical gear on the rear end drives the gear-type lubricating oil pump through an idler gear. A 56-tooth micarta gear, assembled to the crankshaft with a forced fit without keys, is driven by the 28-tooth gear on the crankshaft. A bronze thrust washer at the front end of the camshaft limits the end play to 0.003-0.005 in. Throughout this whole construction can be seen the predominating idea of direct drives and the elimination of unnecessary elements.

Force feed lubrication is used on all main, crankpin and camshaft bearings, all other moving parts in the engine being supplied with splash lubrication. The same principle of directness is evidently adhered to in the design of this lubricating system. Oil from the gear pump, which delivers 1 gal. per 1,000 revolutions of the engine, is fed directly to the rear main bearing and then to the drilled crankshaft for lubricating the main bearings and crankpins. A steel pipe is cast into the cylinder block directly over the wall separating the crankcase from the valve chamber. At the center of the pipe a drilled hole leads the oil to the center camshaft bearing and through an annular groove down through a hole to the main bearing.

At the front end of the cast-in pipe, a similar passage leads to the front main bearing. At this point is also located the spring-loaded ball check vaive for regulating the oil pressure. It will be observed that in this lubricating system the oil feed to the main bearings is direct, and that they are first to be served with lubricant, as they should be.

Oil is prevented from leaking from the crankcase to the flywheel housing by an oil slinger on the crankshaft in conjunction with seals. The crankcase pan is an aluminum casting that extends back to serve also as the lower half of the flywheel housing. A vertical wall in the pan separates the flywheel housing from the crankcase.



Die-cast aluminum fuel pump. Below the inlet near the top of the central "standpipe" is a wire gauze whose outer edge is held between the stamped cover and the body.

Rubber mountings are used at the two front and one rear engine-supports. The ends of the front supporting bracket rest upon rubber pads that are vulcanized into a steel ring which in turn is bolted to the front cross member of the chassis frame. The bolted connection between the ends of the bracket and the rubber mounting is by means of a tapped bushing vulcanized in the rubber. The single rear mounting consists of a steel ring bolted to the front side of the center cross-member of the chassis frame. A ring of rubber is vulcanized to the inside of the steel ring. Two small rods having a flexible connection to the cross-member and rigidly fastened to the engine apparently are for the purpose of damping the engine vibrations and also limiting their amplitude. Incidentally, the fuel supply pipe has a flexible section interposed near the fuel pump so that there will be no tendency for the engine vibration to fatigue the metal pipe.

To provide forced cooling-water circulation, an impeller pump is provided for each side. Also, at the front end on the top is the fan and the generator. A single V-belt drive running over four pulleys, drives both pumps, the fan, and the generator. Another example of making one element serve a number of purposes.

There are only three exhaust outlets on each side of the engine, the center outlet serving the two innermost

cylinders. The cast manifolds have their outlet to which the exhaust pipe is connected, at the front end. The manifold on the left side of the engine, looking from the rear, is connected to a curved cast pipe that runs under the engine to the other side. It is not shown in the picture. On the right side, both this pipe and the right side manifold connect to the main exhaust pipe.

Much more could be written about this epochal engineering design. Many features and points of engineering not mentioned here for lack of space, will be evident. But the most interesting thing about this whole design is the evident meticulous care and thoroughness with which each little detail is worked out. German engineers are traditionally thorough and painstaking, but we venture to say that even they can well take a leaf out of the notebook of Henry Ford's engineers. Merely the appearance of this engine bespeaks careful, efficient, and economical design.

Specifications of Ford Model-18, 90-Deg. 8-Cylinder Motor

Weight of motor	581 lb.
Horsepower rating	30
Brake horsepower	65
Engine speed at maximum power	3400 r.p.m.
Cylinder bore	3 1/16 in. (3.0625 to 3.0635)
Length of stroke	3 3/4 in.
Compression pressure	105 to 114 lb.
Compression ratio	5.5 to 1
Piston displacement	221 cu.in.
Firing order	1-5-4-8-6-3-7-2
Motor suspension	3 point rubber mounted
Engine supports	Supported at 2 points in front and 1 point in rear
Weight of flywheel	32 lb. 2 oz.
Weight of crankshaft	65 lb.
Length of crankshaft	24 3/32 in.
Diameter of main bearings	2 in.
Length of main bearings	Front 1 3/4 in., center 1 11/16 in., rear 2 1/4 in.
How is oil prevented from overflowing rear main bearings?	Oil slinger on crankshaft and oil seal in block
End play of crankshaft	0.004 to 0.007 in.
Diameter of connecting rod bearings	2 3/32 in.
Width of connecting rod bearings	7/8 in.
Weight of connecting rod	465 grams (variation 1 to 3 grams)
Length of connecting rod	7 in. centerline of wrist-pin hole to centerline of crankpin bearing
Clearance between connecting rod bearing and crankpin insert	0.0015 to 0.003 in.
Side play of connecting rod	0.010 to 0.012 in.
Clearance between crankpin inserts and crankpin	0.002 to 0.004 in.
Size of crankpin bearing inserts	2 in. I.D., 2 3/32 in. O.D., 1 15/16 in. long
Length of crankpin bearing	1 15/16 in.
Offset of cylinder bore with centerline of crankshaft	0.265 in.
Main and connecting rod lubrication	Oil pressure through oil holes in crankshaft
Type of oil system	Force feed to all main connecting rod and camshaft bearings, splash to all other working parts
Teeth on oil pump idler gear	25 teeth
Correct oil pressure and how adjusted	20 to 25 lb. Adjusted by screw at front end of motor
Length of piston pins	2 13/16 in.
Oil pump drive	By idler gear which is driven by gear on rear end of camshaft
Diameter of piston pins	3/4 in.
Clearance between piston pin and connecting rod bushing	0.0002 to 0.0003 in.
Size of camshaft bearings	1.798 to 1.799 in.
Length of camshaft bearings	Frt. 1 3/32 in., Ctr. 1 3/8 in., Rear 2 5/16 in.
Number of camshaft bearings	3
Clearance of camshaft bearings	0.002 in.
Number of teeth in small time gear	28
Number of teeth in large time gear	56
Number of teeth in camshaft oil pump drive gear	12
Size of valve ports	1 3/8 in.
Size of manifold ports	1 3/8 in.
Valve lift	0.300 in.
Valve clearance	0.015 in.
Valve spring tension	40 to 42 lb.
Size of valve head	1 1/2 in.
Type of piston	Split skirt
Diameter of skirt	3.060 to 3.0615 in.
Width of ring land	0.133 to 0.134 in.
Clearance of pistons in cylinders	0.0005 to 0.003 in.
Size and number of oil rings	3/32 in., one each piston
Clearance of piston rings in piston	0.001 to 0.0015 in.
Width of compression rings	3/32 in.
Distance between piston bosses	1 7/16 in.
Diameter of standard piston	3.0605 to 3.0615 in.
Size of piston pin hole in piston	0.7499 to 0.750 in.
Weight of piston	287 to 291 grams
Number of cylinder head studs and their length	11 studs 3 1/2 in. 5 studs 2 3/4 in. 5 studs 2 1/4 in. } each block
Size of spark plugs	7/8 in.

The MONTH in PRODUCT DEVELOPMENT

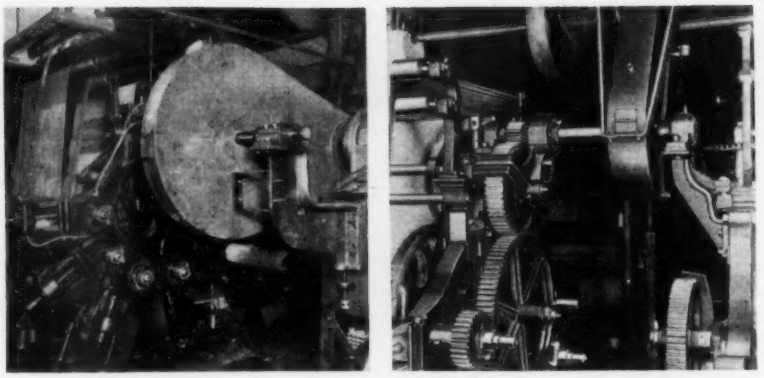
▸ New Material Uses

Aluminum hopper cars of 70-ton capacity have been manufactured by Canton Car Company. Except for trucks, brake equipment, safety devices, draft gears and couplers, center plates, and rivets, all parts are aluminum. All highly stressed members are heat-treated strong aluminum alloy 17 ST. Body sheets are 4 S alloy plates, ¼ and ½ hard temper. Castings in the car body are 197-57 aluminum alloy, selected for its strength and shock-resisting qualities. The built-up center sill uses ½-in. web plates, angles, and cover plate. Body side sheets are ¼ in., and the floor sheets ⅜ in. The side sub-sills are 8-in. 4.89-lb. channels, and the end sills are 10-in. 8.84-lb. channels.

Aluminum wheelbarrows have made their appearance. Weighing only 37 lb., they permit a 15 per cent increase in "pay load." One make is all-aluminum. Another has a pneumatic tire and anti-friction bearings.

Covering of industrial and consumer products with "anode" rubber to resist abrasion or corrosion is being used increasingly. Recent applications are: impellers used in exhausting rock dust in construction drilling; meshed wire baskets for dipping operations in corrosive acids; plating racks; spinnerettes used in rayon manufacturing, and screens used in copper stamp mills. Usually this "anode" rubber is applied electrolytically, but recently the same type of coating has been secured by dipping the work in a coagulent and then in latex. Vulcanization is required after several dippings.

Strontium chloride powder, with lithium nitrate as a binder, is used as an absorbent in the "Faraday" gas refrigerator, a new product of General Motors. The refrigerator uses 7 lb. of chloride.



Left—In this textile printing machine the drive takes up much room and interferes with making necessary machine adjustments. Right—Here the end frame of the adjacent machine is designed to carry the pedestal for the outboard bearing. Drive is from an overhead countershaft, and the star gear can be changed without disturbing the drive shaft

▸ New Applications of Parts and Units

Pneumatic tires, as noted above, are now being applied to the lowly wheelbarrow, the selling argument being that it makes them easier to push, hence greater loads. For the same reason, anti-friction bearings are used.

As commonly used for this type of equipment, a double-acting hydraulic piston raises and lowers the scraper attachment for tractors, developed by the Blaw-Knox Company. A single control holds the scraper or "bull-dozer" with its cutting edge at the desired elevation. If a large boulder or other immovable obstruction is encountered, a by-pass safety valve in the piston allows the bowl to lift, thus saving breakage, distortion, and repairs.

▸ Redesigned Machine Drive

The accompanying pictures show the old and the new drive for a textile printing machine, designed by Rice, Barton & Fales. The old design took up too much room and when it was necessary to change the star gear to suit different patterns the drive shaft had to be realigned, usually resulting in an imperfect mesh between the teeth of the driving pinion and the main gear. This caused chattering of the gears, rapid wear, and eventually a second grade of goods coming off the machine. The old change gear principle used on lathes was adopted to make it possible to change the star gear without disturbing the drive shaft. In addition to the changes evident from the pictures, all bearings are of the antifriction type; where necessary they are self-aligning. Sprockets, gears, and pulleys are designed to commercial proportions for quick and less costly replacement.

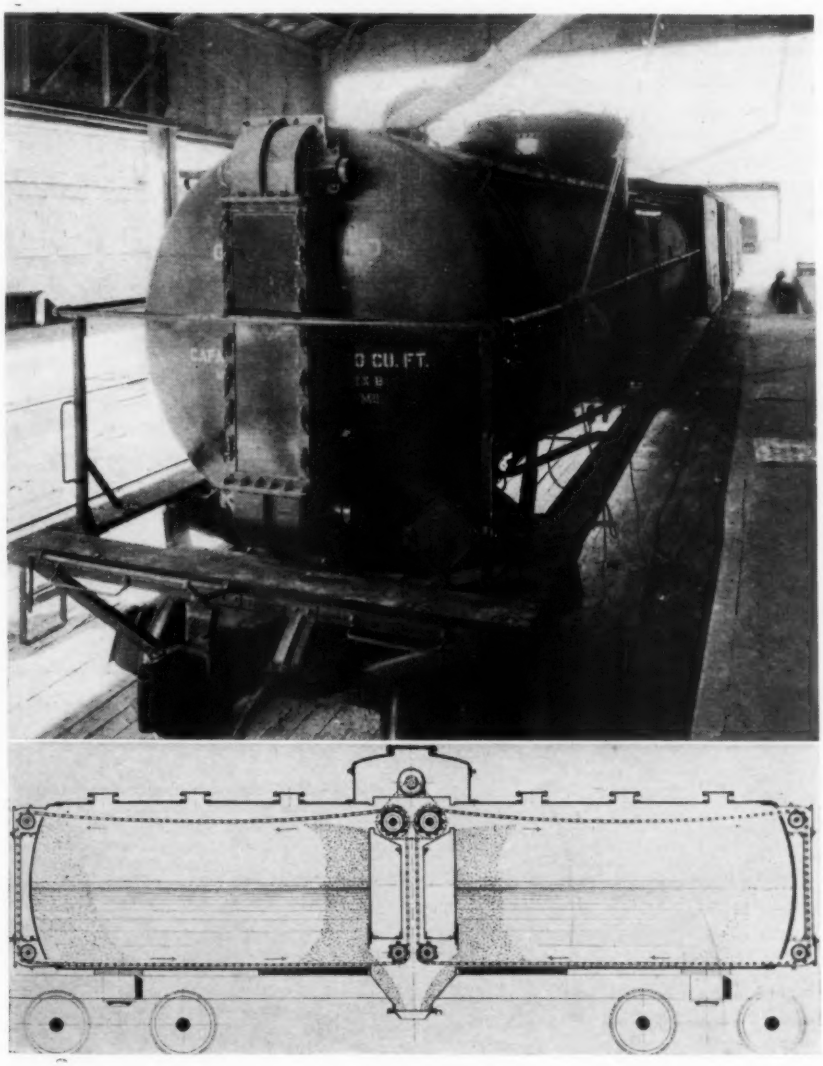
▸ "Dry-Flo" Tank Car

Elimination of packaging and simplified handling of such bulk commodities as cement and quick lime feature General American Tank Car Corporation's "Dry-Flo" car illustrated. Granular material is transported in a tank car and is discharged from a central hopper by a pair of Link-Belt chain conveyors with flights

2 in. high. Moving at the rate of 10 ft. a minute, the chain carries along with it material to a height of 10 in. Drive from the ball-bearing electric motor is through a "Twin Disc" friction clutch to two "Helicentric" speed reducers by heavy-duty roller chains. Idler and driving sprockets are in chambers outside the material compartment which follows standard tank car construction. The car can be unloaded in two hours.

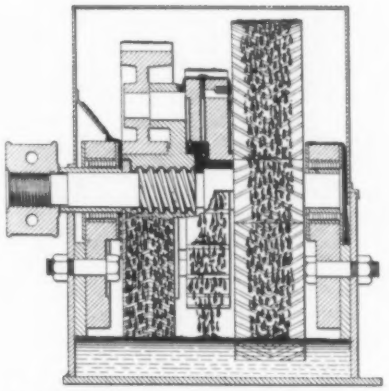
The first model had two screw conveyors at the bottom each feeding toward the hopper in the center. It was found, however, that when a heavy substance like cement was moved a few hundred miles it packed so solidly that the conveyors could not be turned, even with an excessive amount of power.

Arching of the material was effectively eliminated by providing slope sheets only on two sides and leaving the car ends slightly concaved as in standard tank car construction. Loading takes place through six manhole covers made water and dust proof by gaskets. The unloading hopper is also equipped with a gasketed sliding gate which can be bolted and sealed for shipment.



▸ Herringbone Gears for a Double Purpose

O. L. Coffey, development engineer, Whiting Corporation, informs us that in hoisting-load brakes such as the one illustrated—which is used on their "Tiger" cranes—all the work done by the load itself in lowering, plus the energy supplied by the motor to keep the brake unlocked and ahead of the load, is converted into heat. In conventional designs no provision is made for dissipating this heat except by direct radiation, with the result that the friction surfaces become extremely hot and wear rapidly. In the design illustrated, oil flushing is provided, both to carry away the heat and to keep the friction surfaces well lubricated. One of the unusual features of this design is that the oil circulation is accomplished without the addition of a pump yet it is a forced circulation.



In this mechanical brake, forced circulation of oil between the brake plates is obtained by the pumping action of the herringbone gears. The path of the oil flow is indicated by the arrows

It was noticed that, as the teeth of herringbone gears are coming into mesh, oil is either forced out or sucked in between them. The path of the oil flow is along the tooth, either from the apex to the ends of the tooth or in the opposite direction, depending upon the direction of rotation of the gears. By substituting herringbone gears for the spur gears formerly used, and taking advantage of this pumping action, a forced circulation of oil to lubricate the brake was obtained.

At the pitch diameter of the drum pinion, holes are drilled in the steel friction collar, which is part of the brake. Oil is thus forced into the brake during lowering. No braking is done during raising, so that the suction effect of the gears during their reversed rotation is not a drawback. A large capacity sump in the welded steel base contains sufficient oil to absorb and dissipate the heat without a high increase in temperature.

▸ Contractor's Equipment

Cement shipped in bulk is obviously cheapest, but how can it be unloaded economically? Now comes a portable conveyor-elevator that handles 110 to 200 barrels per hour. The outfit consists of a horizontal and a vertical spiral screw. Both screws are mounted in dust-proof welded

casings. The casing for the horizontal screw may be adapted to special hoppered cars or to box cars. Bulk material is conveyed through the horizontal conveyor, the vertical conveyor and then drops into a storage bin.

Another type of unloader embodies a hinged car hopper adjustable to the car height for the use of either buggies or scoop shovels. A 4-cylinder engine operates the inclosed screw conveyor, which loads a 1,000-lb., double-beam cement weighing scale. The screw is run at an angle from the hopper to a bin supported at suitable height for loading trucks.

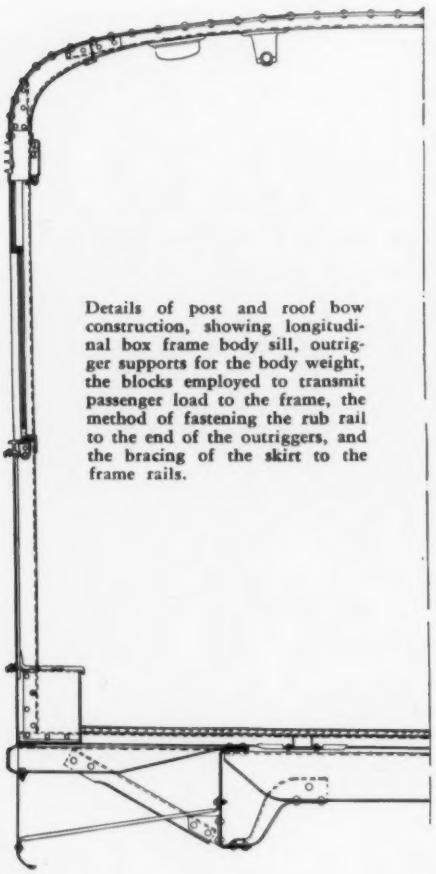
Loading end-gate in lowered position. The lifting mechanism is hydraulically operated

▸ Bus with Dural Body

Slicing body weight by extensive use of duralumin permits Fargo to offer two buses meeting operators' pressing requirements for equipment having better operating economy and lower taxation cost. Vehicle weights per seat are but 451 lb. for the 29-passenger parlor coach and 364 lb. for the 35-passenger city bus.

The body shell is all-metal construction. Roof carlines and body posts are rolled from duralumin. These sections are joined at the upper belt by steel knee braces. At the bottom, body posts are secured to box-type longitudinal sills, and to channel or box-type cross members, by stamped gussets or forged brackets of duralumin.

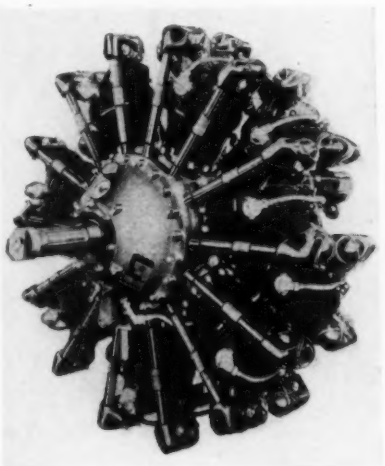
The front end of the body is a vertical buttress with channel posts supporting a frame of welded angles to carry the windsheld, front wheel house and dash. Side panels of duralumin are riveted to posts, belt rail and sills. A cork lining trim on the inner side insulates the body. Roof exterior is of formed duralumin plate riveted to the roof members. Between the roof sheets and the interior Masonite sheets, are used for insulation. Plymetal hardwood flooring is covered top and bottom with aluminum, and provides a moisture-proof base for the linoleum floor covering.



Details of post and roof bow construction, showing longitudinal box frame body sill, outrigger supports for the body weight, the blocks employed to transmit passenger load to the frame, the method of fastening the rub rail to the end of the outriggers, and the bracing of the skirt to the frame rails.

▸ Unusual Design of Truck End Gate

Development of a hydraulically powered, automatically controlled, truck end gate is announced by the Isaacson Iron Works, Seattle. The purpose of this gate, which can be raised or lowered, is evident from the accompanying illustration. The gate position at the ground or body level is automatically controlled, requiring no manual attention. Operation is through a standard transmission power take-off and a controlled hydraulic pump and cylinder. The lifting mechanism is inclosed in a sub-frame mounted on the chassis. By means of positive control, the position of the gate can be adjusted



"Twin Wasp Junior", Pratt & Whitney, is their first two-row radial engine. Small frontal area, over-all diameter 43⅞ in., and high horsepower output are for the purpose of getting faster planes and higher performance characteristics. Output is 625 hp., 2,100 r.p.m.; weight is but 830 lb. Length of the engine is 48¼ in. Two banks of 7 cylinders each are staggered for most effective cooling. Engine No. 1, furnished to the Navy, is built for direct drive, but propeller reduction gearing is possible. Radio shielding permits transmission and reception and also the use of a two-way telephone system

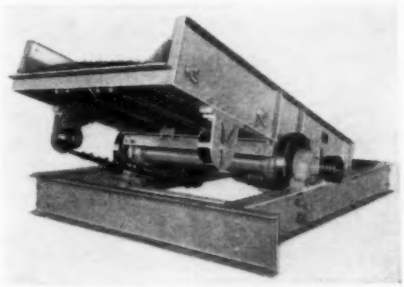
Photoengraving machine in which photograph is put on a revolving cylinder and scanned by an "electric eye." Through amplifiers, "eye" operates an engraving tool which gouges out corresponding light and dark areas on plate which is then mounted on "type high" block. Time, 5 minutes

for various height platforms or at the curb, the entire gate movement being under the driver's control by means of two levers.

▸ New Vibrating Screen Mounting

Formerly, the Link-Belt vibrating screen, the redesign of which is shown here, was supported through four spiral coil springs, in the same location as those shown in the picture. With heavy loads on the screen, the springs would sometimes "bottom." In the new design two spiral springs on each side are in one piece with one of the bands of the cantilever spring. The cantilever springs are mounted on the screen foundation so that by loosening two bolts on each side the screen can be tilted to the most suitable angle, a flexibility which the previous design did not possess.

This one-piece leaf and spiral spring construction has increased the amplitude of the vibrations and in addition has overcome the "bottoming" on heavy loads. The screens are furnished with either a flat-belt pulley or a grooved pulley for a three-strand V-belt drive.



In this vibrating screen the two spiral springs on each side are in one piece with one of the leaves of the cantilever spring

▸ Business Machines

An electrical multiplying machine that operates on the punched hole principle has been developed by International Business Machines Corp. The items to be multiplied are first punched in separate columns of tabulating cards. The cards are then fed automatically into the electrical multiplier. Contacts of tiny electrical brushes are made through each of the punched holes in the cards, each contact causing an electrical impulse that registers the corresponding number and performs the arithmetical operation by means of the mechanism within the machine. Actual multiplication principles are utilized in electrically determining the product of two numbers, however complicated. Partial products are automatically added to give the final product. The machine is adapted to large scale work involved in accounting systems of public utilities, railroads and insurance companies.

▸ Thermostats

In a thermostat some of the design problems are: sensitivity, positive, non-fluttering action, and operation on line or low voltage. In one type offering extreme sensitivity of $\frac{1}{2}$ deg., a spiral bimetallic element has one end fixed to the temperature range adjustment lever and the free end carries a small permanent magnet. When room temperature falls below desired point, the magnet approaches a "Mercoid" switch. The movable armature within the switch is drawn toward the magnet and closes the circuit. The thermostat is noiseless in operation. Since this type operates on 24 volts, it requires a transformer repulsion relay. When the thermostat closes, the circuit current flows in the two transformer coils, which are mounted on an iron yoke that affords a common magnetic circuit. The free coil moves because of the repulsion effect and closes the circuit through a Mercoid switch. This device is also inherently noiseless in operation. Another thermostat incorporates a permanent magnet to give positive snap action to the contacts. Still another type employs a "solid filled" bellows $\frac{9}{16}$ in. in diameter which is considered small, but which gives positive action to the movable contact linkage.

Eight figures are multiplied by eight figures in less than eight seconds on this electrical multiplying machine, which is said to operate four times faster than mechanical methods

The Present Status of the "Electric Eye"

BACK in 1883, when the inventor of the incandescent lamp, the phonograph, the microphone and a legion of revolutionary devices was experimenting with one of the grandparents of the modern Mazda, he noted a flow of electrons from the hot filament. Though the electron was not named by G. Johnstone Stoney until 1891, Edison built a few bulbs with plates alongside the filaments in vacuo, measured the current which flowed in these pioneer electronic rectifiers, recorded his experiments and went on to work in other fields.

For twenty years the principle lay relatively fallow. But in the early part of this century, the "Edison Effect" was brought from hiding, dusted off and made the basis for the enormously diversified family of devices which underly radio, sound pictures, television, long distance telephony, and all the host of familiar and unfamiliar electronic phenomena. At just what date the "electric eye" (which is not to be confused with the amplifier tube) began its more specialized yet versatile career is subject to argument, but there can be no controverting the fact that it has arrived to stay. Since its importance to engineering may scarcely be estimated, it would seem timely to summarize briefly the present status of the art in a non-technical way and to try to list some of the countless ways in which all of us may capitalize its capabilities.

▼

Sensing the widespread interest in the subject and the need for a short, non-technical summary of the photocell situation, we have secured the following data through the courtesy of the editors of *Electronics* and *Power* and other competent authorities. For succeeding issues we have in preparation further articles on how certain machines are being redesigned to take advantage of photoelectric operation.

▲

The light-sensitive devices, known popularly as "electric eyes," are of several different classes, each based upon widely differing physical phenomena. Each has special characteristics which adapt it for particular uses. These different kinds of "eyes" may be listed as follows:

1. The photoelectric-tube—a vacuum or gaseous cell, with light sensitive plate which emits electrons upon illumination. The resulting current produced by the stream of electrons is then amplified by other types of electronic tubes.
2. The selenium cell—the familiar element which changes its resistance with incident illumination. In its latest forms it is sealed in vacuum tubes.
3. Photo-voltaic cells, or "light" batteries, which produce a change in current flow with changes in illumination.
4. Dry oxide plates (copper oxide, etc.) which produce comparatively large low-voltage currents when illuminated.

In general, where a beam of light can be interrupted, modulated or controlled by some operation which is to be counted, detected or reproduced, a light-sensitive unit of one of the types heretofore listed can be employed. *This can be done without interfering with the action to be recorded.* In certain more specialized devices, "black light" from the invisible bands of the spectrum may be utilized, thus making possible the invisible guarding of bank vaults and the like. Then too, certain electric eyes, insensitive to the longer waves of sunlight, may be employed in broad daylight.

As an example of how the "eyes" do not interfere with an action to be recorded, one may employ such devices to regulate clocks from a master clock. In fact one may drive other

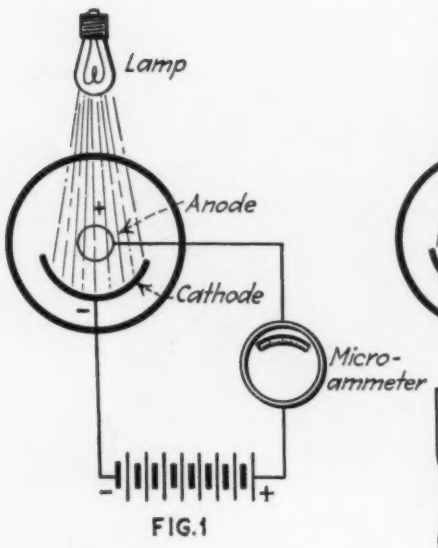


FIG.1

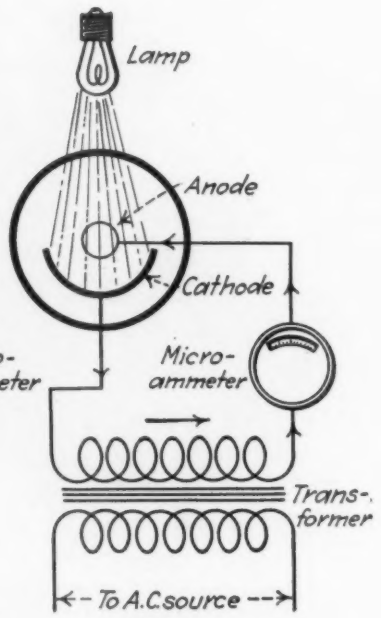


FIG.2

Fig. 1—Diagram of photocell connected to battery. Fig. 2—Photocell connected as a rectifier

The "electric eye" solves the time-hallowed engineering problem of how to register weights without impairing the accuracy of the scale. Here a photocell is mounted behind a slot in the scale dial and is "eclipsed" when any predetermined weight of loose material has been poured into the scale hopper

clocks from the master without loading it in any way. A beam of light and a photocell will accurately record the swings of the master's pendulum without imposing on pendulum or gear train the slightest interference with their functioning or precision.

To avoid confusion in this brief summary, it may be well to confine our discussion to the first classification on the list—the photoelectric tube or cell.

As suggested above, photoelectric tubes are available in both the vacuum and gas-filled types. The latter will pass higher currents than those of the vacuum type because of the phenomenon known as gas amplification. The construction of the photoelectric tube is relatively simple since it contains but two elements: the anode and the cathode. The cathode consists of a curved metal plate sensitized with any one of several alkali metals such as sodium, potassium, lithium, rubidium, caesium. The anode may be in the form of a metal ring or grid, so located in the tube that light passes through it before striking the cathode.

In Fig. 1 is diagrammed an elementary photo-electric tube d.c. circuit. The battery gives the anode positive potential and the cathode negative. But under ordinary conditions no current will flow. If light is allowed to pass through the anode onto the cathode, electrons are released from the latter and attracted to the former. In this way the space between the anode and cathode becomes a conductor and a current begins to flow in the circuit. Cutting off the light causes the space between the anode and cathode to become an insulator; the current flow in the circuit stops instantly. Varying the light intensity will cause the flow of current through the tubes to change almost exactly in proportion to the amount of illumination reaching the cathode.

Current will flow only from the anode to the cathode. If the polarity of the tube is reversed, that is if the cathode, Fig. 1, is made positive and the anode negative, no current will flow in the circuit. Thus it will be seen that the tube may be used to rectify a.c. current.

If the light is allowed to shine continuously on the cathode, as in Fig. 2, current will flow in the circuit during the half of the a.c. current cycle that the voltage is in the direction shown by the arrows, that is in a direction which makes the anode positive. During the half cycle when the voltage is reversed, no current will pass through the circuit. The result of such an operation will be a series of current impulses in the circuit as shown by the curves in Fig. 3. The spaces between the curves represent, of course, the periods when the direction of the voltage was from the cathode to the anode, that is when no current was flowing in the circuit. By connecting two tubes in the circuit a continuous series of current impulses can be had as indicated by the curves in Fig. 4, where each alternation is rectified.

Connected with suitable amplifiers and relays, photoelectric tubes of proper design can be made to produce an almost infinite variety of actions. In addition to ones responding to light intensity, tubes sensitive to the various colors in light are available; these are particularly useful for distinguishing and matching colors.

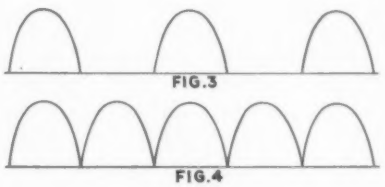
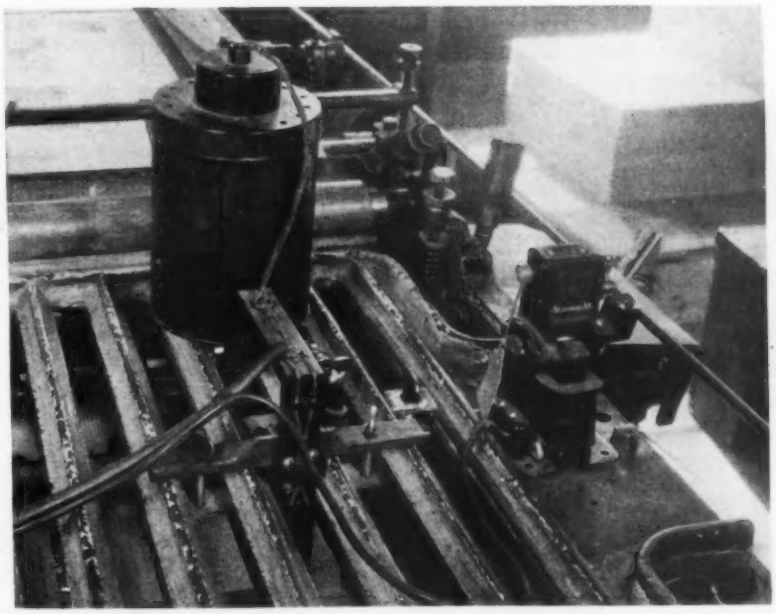


Fig. 3—Curves represent current flow through photocell, Fig. 2. Fig. 4—Two photocells properly connected to a transformer would give a current represented by these curves

The current that a photoelectric tube will pass is small, being only a few hundred micro-amperes at the most. Before such a small current can be utilized, it must normally be amplified through vacuum tubes, such as are used in radio work, be-



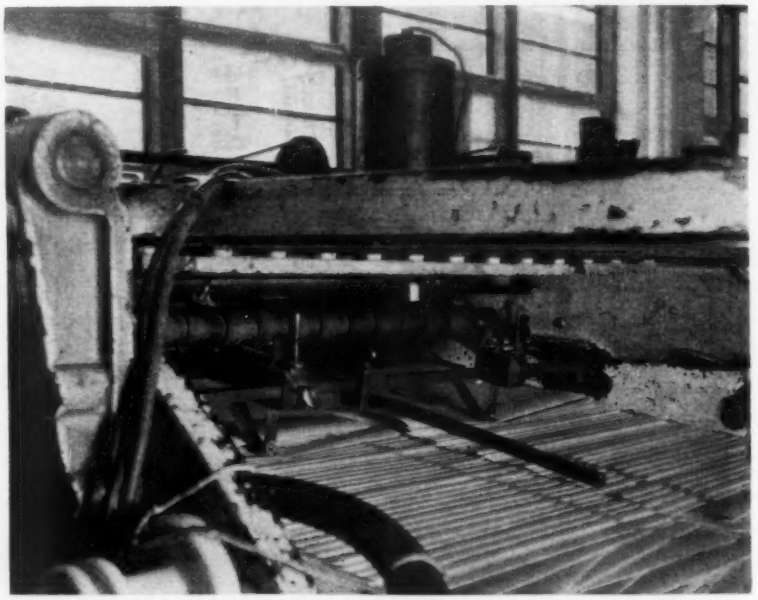
Top view of rough-and-ready photocell installation in our own bindery. As sheets drop through the folding machine they interrupt a beam of light thrown downward from the "can" to a standard Weston Photronic Cell which feeds into a Weston Instrument Relay, thus breaking current across the contacts. The count is registered on a Veeder electro-magnetic counter

fore it can be used to operate a relay, which in turn may control a thousand amperes. The magnitude of any current that can be passed through a photoelectric tube will depend upon the nature of the metal on the surface of the cathode, the color and intensity of the light, whether the tube is gas-filled or a vacuum, and the potential applied to the anode. The potential may vary from about 30 to 300 volts, but many of the tubes in most active use are designed for 90 volts.

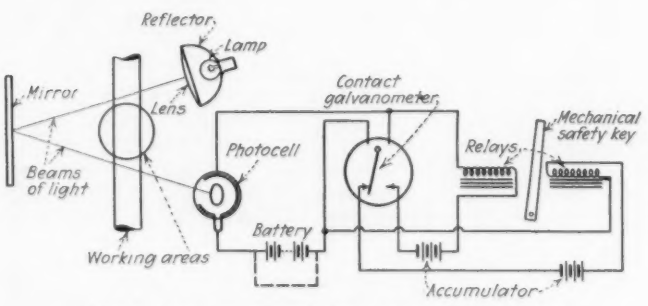
Without going into the infinite variety of circuits to which the photoelectric tube may be implied, it will be seen that its characteristics make it applicable to an infinite variety of industrial, commercial and home uses. In the shop it can do the relatively menial job of counting parts as they swing down the production line or it can be made to gage the same parts to super-micromatic exactness. In the power house it can record the density of the smoke going up the stack and it can keep close watch on the turbidity of the feed water so that it may be properly treated. In the commercial house or bank, it will control interior illumination or tabulate statistics or guard the safe. Though its applications to home devices are still few in number, they are bound to become legion; already it will keep its electric eye on the pilot flame of oil-burner installations—should the flame fail, it will shut off the oil flow immediately; it will open doors automatically as one's shadow interrupts a beam of light shining on it, perhaps invisibly; it will guard windows and outside doors against intruders. One need but listen for a few minutes to an electronic engineer to realize the enormous present and future possibilities of the electric eye.

The past year has been marked by the rapid increase in the number, diversity and ingenuity of application of the various forms of electric eyes. Engineers have suddenly come to realize the usefulness of these remarkable new tools in taking the place of human scrutiny and drudgery in the performance of routine yet essential tasks. But times without number, if our correspondence can be relied upon as a guide, these same engineers have hesitated to incorporate electric eyes in their various machines and products. To any engineer but an electronic specialist the circuits appear to be complicated and in some instances incomprehensible. This is particularly unfortunate because at least nine American firms are in the field with standardized, fully proved devices (some photocell, some selenium cell, etc.) which incorporate the necessary amplifiers, relays, wiring, etc., in self-contained and readily attachable units. These require only the simplest forms of electrical connections. The following manufacturers are prepared as part of their service to advise any and all engineers on the applications of their particular products:

Allen-Bradley Co., Milwaukee, Wis.
Burgess Battery Co., 202 East 44th Street, New York.
Clark Instrument Co., Camden, N. J
General Electric Co., Schenectady, N. Y.
G-M Laboratories, 1735 Belmont Ave., Chicago.
Lux Tron Mfg. Co., Inc., 241 Lafayette St., New York, N. Y.
Struthers Dunn, Inc., 148 N. Juniper St., Philadelphia.
Westinghouse Electric & Mfg. Co., Pittsburgh.
Weston Electrical Instrument Corp., Newark, N. J.



Bottom view of same bindery installation, the success of which incidentally should inspire the designer to incorporate the photocell counter in a new model of the folder. The Weston Photronic Cell will be seen just under the "can," but the relay is hidden in a metal box on the floor beneath



Simple circuit employed for a punch press guard. Countless circuits may be devised easily with the standardized parts available on the market

The further adoption of electric eyes will depend upon public recognition of needs and uses for them plus the ingenuity of engineers and production men in fitting them into the problems and products of the workaday world.

[Editor's Note—*Many applications of photoelectric cells and other electronic devices cannot be described until patent formalities are cleared away. We would be glad to hear of applications whose engineering details can be published currently.*]

Effect of Variable Friction in Differential Brakes

GEORGE W. MORK
Designing Engineer

Unless a differential brake or self-energizing clutch is operating under almost perfect conditions, free from dirt and temperatures fairly constant, the lining is likely to become so sensitive that effective operation is greatly impaired.

This sensitivity is undoubtedly due to the effect of moisture, temperature, dirt, grease and oil. It is well understood that temperature is a vital factor in the variations of coefficient of friction in the average commercial brake lining. A clutch or brake in intermittent or slipping service will without doubt have an extensive temperature variation, thus affecting the characteristics of the lining. When such a clutch or brake is used on a hoist or any type of machine which

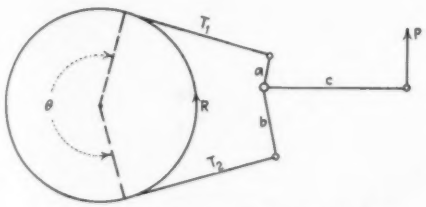


Fig. 1 — Example of differential brake linkage

does not provide, because of mechanical structure, perfect protection from the elements or proper seals from oil and grease, trouble will be multiplied.

To illustrate mathematically the effect of friction variation, I have taken a simple differential brake as shown in Fig. 1. For the equation for the external moment, let:—

T_1 = dead end load
T_2 = live end load
P = actuating force
u = coefficient of friction
R = rim force or tangential load

Then

$$T_1a + Pc = T_2b$$
$$Pc = T_2b - T_1a \quad (1)$$

From the general equations for brakes we have:

$$T_1 = \frac{e^{u\theta}}{e^{u\theta} - 1} R \quad (2)$$

$$T_2 = \left(\frac{e^{u\theta}}{e^{u\theta} - 1} - 1\right) R \quad (3)$$

Substituting Equations (2) and (3) in Equation (1) and simplifying we have:

$$Pc = \frac{e^{u\theta}}{e^{u\theta} - 1} (Rb - Ra) - Rb \quad (4)$$

We will now let the value u vary between the limits zero and infinity in Equation (4) to see how Pc is affected. Letting u approach zero:

$$Pc = \frac{1}{1 - 1} (Rb - Ra) - Rb$$
$$= \infty$$

Then letting u approach infinity in the same equation, we have:

$$Pc = \frac{\infty}{\infty - 1} (Rb - Ra) - Rb$$
$$= Rb - Ra - Rb = -Ra$$

Then

$$Pc = -T_1a$$

This solution is correct since, as u approaches infinity, T_1 approaches R and T_2 approaches zero. Therefore Pc must be equal and opposite in direction to T_1a. It is generally understood that infinity divided by infinity is an indeterminate quantity. However, in this case it is readily seen that as $e^{u\theta}$ grows larger the first term of the right hand member of Equation (4) approaches unity.

We have now shown that as u approaches zero the brake engaging moment approaches infinity, and as u nears infinity this same moment approaches a finite value $-T_1a$. In other words, if the coefficient of friction is a variable factor in a differential brake or self-energizing clutch,

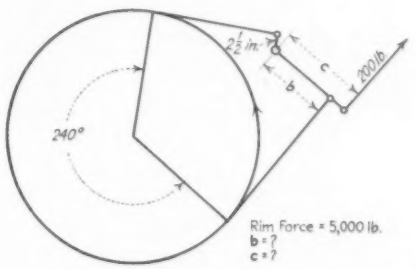


Fig. 2—Proportions of linkage used in the example to show the effect of a variable coefficient of friction

the effort required to engage becomes greatly variable. Unless the lining is protected against the influences enumerated before, a linkage with a variable mechanical advantage must necessarily be used to compensate, when necessary, for any change in friction. This same analysis will, of course, also apply to any brake or clutch, but for other types it is not so serious.

In Fig. 2 is shown a practical application, with curves plotted to illustrate the critical point which is very apt to make itself evident if a linkage of variable mechanical advantage is not used.

(Continued on page 206)

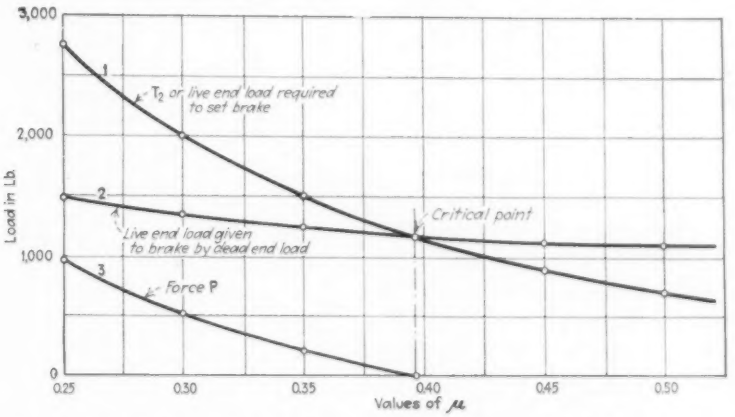


Fig. 3—Relation between the value of the coefficient of friction and (1) the live end load required to set the brake, (2) the live end load, and (3) the force applied

Sleeve-Type
Light and

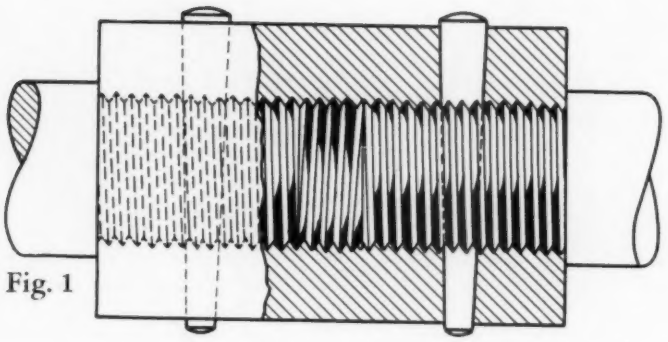


Fig. 1

Fig. 1—For low speeds and torque, this type of screwed sleeve coupling is compact and economical but has the disadvantage of being difficult to machine with sufficient accuracy to assure perfect alignment of the connected shafts. The taper pins prevent unscrewing of the coupling.

When over-all outside diameters are limited, the sleeve-type coupling often solves the problem. Various constructions to meet different conditions are given here, together with the fundamental design considerations

Fig. 2—Tapered sleeve couplings such as shown here transmit the torque by the frictional grip of the sleeve on the tapered shaft. Assuming that inaccuracies in machining might cause the grip on the shaft to be near the inner end of the sleeve taper, it is evident that the effective diameter of the shaft will be reduced to some such value as indicated by d, the diameter at a point about $\frac{2}{3}$ in. from the end of the sleeve.

The diameter d can be found from the equation:

$$\frac{\pi d^3}{16} = \frac{63025\ hp.}{n\ S_s}$$

hp. = horsepower transmitted
n = speed of rotation
S_s = allowable unit shearing stress

The required frictional grip of the sleeve on the shaft can be calculated from the torque to be transmitted, assuming a coefficient of stationary friction of 0.3 for steel on steel. For a total pressure P, the tangential force will be 0.3 P, which multiplied by one-half of the effective diameter d, gives 0.15 Pd for the turning moment. Hence:

$$0.15\ Pd = \frac{63025\ hp.}{n}$$

For a taper of 7 deg. the tensile pull T required to create the force P will be:

$$T = P \sin 7\ \text{deg.} = 0.121\ P$$

The shaft diameter d should then be recalculated for combined tension and torsion. The threaded ends of the shafts are calculated for the tension T.

It will be noticed that unless pilots are specified for tapping the V-threads in the sleeve, the coupling will probably throw the shafts out of alignment. An improvement would be to use loose fitting square threads which would allow the shafts to seat

Fig. 3

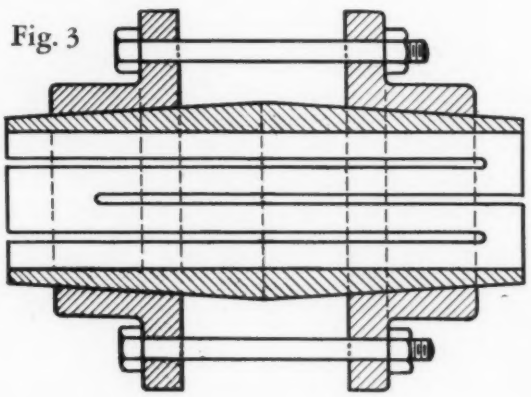
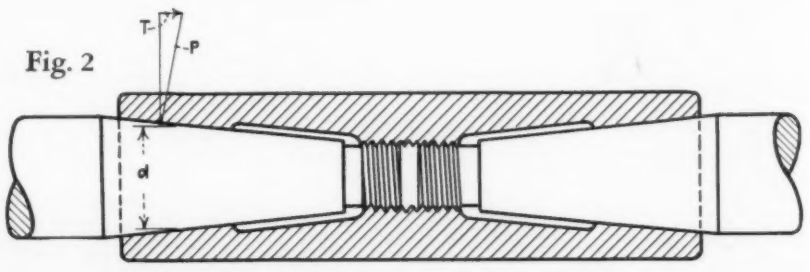


Fig. 2



Shaft Couplings

Heavy Duty

properly in the sleeve. With the length of contact between the sleeve taper and shaft equal to or greater than the effective diameter *d*, the concentricity of the tapers will then be the only factor determining the accuracy of the alignment.

For torsional vibrations and reversals of direction, taper pins as in Fig. 1 should be added.

Fig. 3—The tapered segmental bushing with flanged hubs for creating the grip on the shaft, involves the same design principles as explained under Fig. 2. The advantages of this construction over the tapered sleeve are that fewer accurate machining operations are required to assure alignment of the shafts, and no machining operations are required on the shaft if finished shafting is being used. On the other hand, this coupling is not as compact as the tapered sleeve type shown in Fig. 2. Tension in the bolts is calculated in a similar manner as used in calculating the shaft tension *T* explained under Fig. 2.

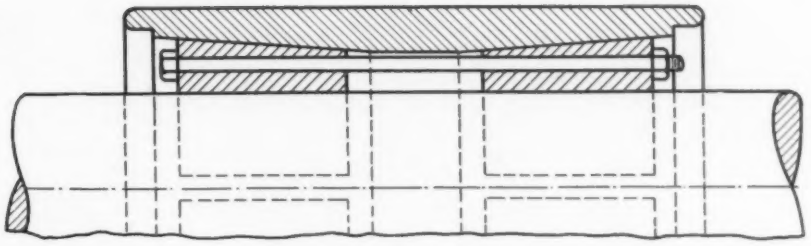


Fig. 4

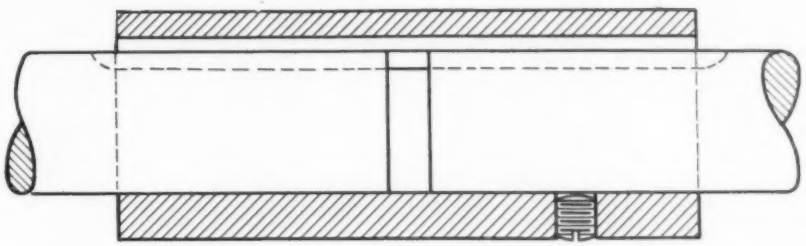


Fig. 5

Fig. 4—Another type of tapered sleeve coupling. This design is more compact but involves a greater number of parts. It is not suitable if accurate alignment is essential.

Fig. 5—Under some conditions, a plain keyed sleeve coupling can be used. A setscrew prevents the sleeve from creeping. For very light loads, two set screws only, bearing on a flat on each shaft, need be used.

Fig. 6—The common clamp or compression coupling can be used for heavy loads where room permits and appearance is not a factor. In addition to being inexpensive, it has the advantage that it can be taken off completely without disturbing the shafts. These couplings are usually of cast iron, are of a more or less standardized design, and can be purchased as finished units.

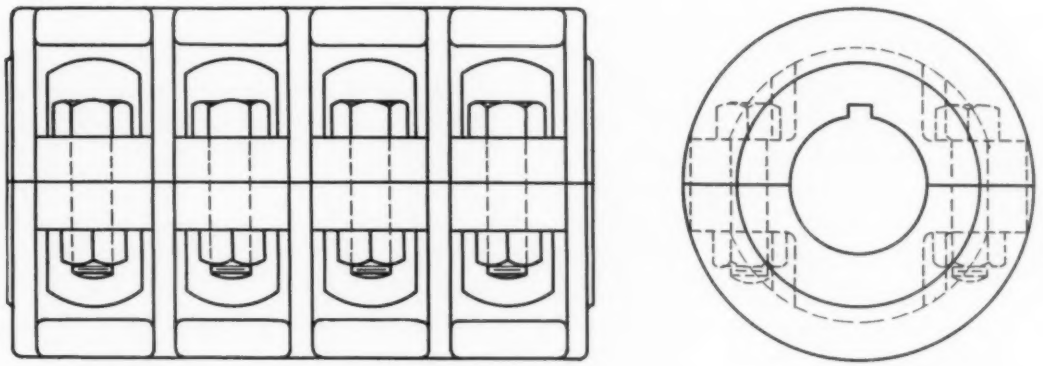


Fig. 6

Bolt Sizes

Up to $1\frac{7}{16}$ in. diam. shafts – $\frac{5}{8}$ in. bolts

$1\frac{1}{2}$ in. to $3\frac{1}{4}$ in. Shafts – $\frac{3}{4}$ in. bolts

$3\frac{1}{4}$ in. to 5 in. Shafts – $\frac{7}{8}$ in. bolts

EDITORIALS

KENNETH H. CONDIT
Editor

Patents and Patent Values

Newspapers and magazines are extolling the beauties and conveniences of the elaborate new quarters of the U. S. Patent Office in the north section of the new Commerce Department Building, Washington, D. C. And there are numerous reports of hearings on the proposed revision of our patent laws, much space being given to arguments pro and con regarding suggested changes. As if to emphasize further the question of patent values, we see the balance sheets of our corporations with the item "Patents" representing, in some instances, a large portion of the asset side of the sheet.

With all this attention being focused on patents, it would be well for executives to reflect for a moment on the real value of patents. Some manufacturers take a realistic view of the value of their patents; they recognize their evanescent and evaporative qualities and group them on their financial statements as "patents and good will"—one dollar. Others rate this same item in six figures or more. Which is correct?

Some patents, probably not more than one in one hundred thousand, have tremendous commercial value. But new and unexpected discoveries or developments may suddenly wipe out the earning power of any patented product. Even with patented scientific discoveries of a basic nature this is true, as shown by the great rapidity with which successive radio patents have outmoded one another.

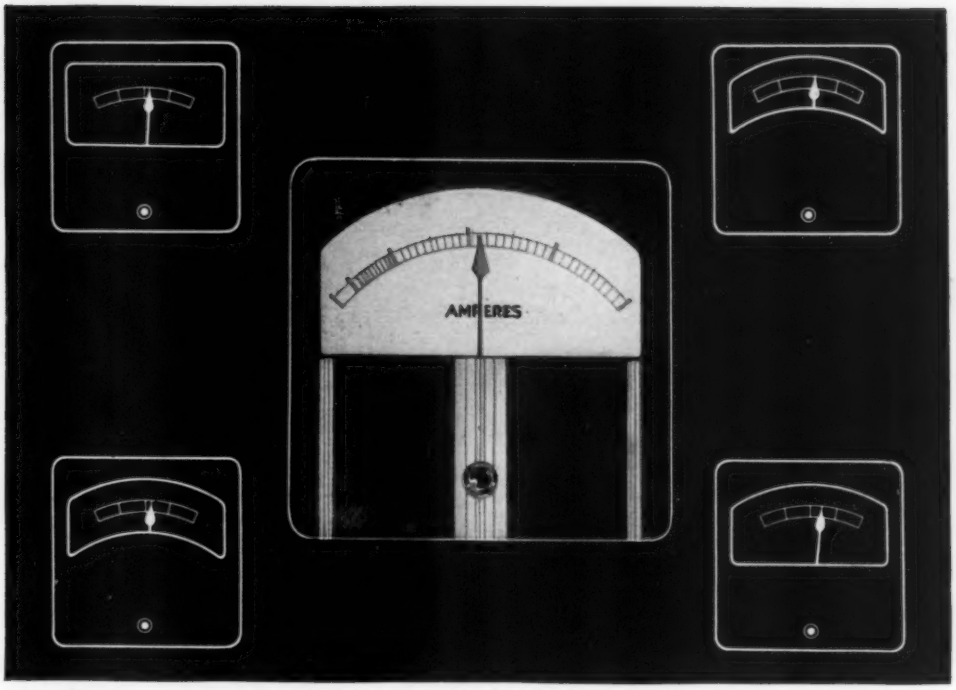
Most of the patents with which product engineers are concerned are of a design nature. Experience has shown repeatedly that such patents have in themselves little value. The patent claims may almost always be gotten around or an entirely different type of mechanism designed to get the same results. Not until the idea behind the patent has been engineered to a high degree of commercial perfection does the patent have any real value. The world's most wonderful patent in the hands of incompetent designers will be worth little or nothing.

Not good will and patents, but good will plus unhampered engineering ability. With these two items on the asset side of any balance sheet, the question of patents will take care of itself. It will make little difference whether they are rated at $1 or $1,000,000, the results will be the same. We wish that every manufacturing executive could appreciate that a patent merely paves the way for a product, the potential profits of which will be in direct proportion to the degree of perfection of the engineering development. And whether we are riding a wave of prosperity or drifting in a depression, product development must be continuous and of the highest quality.

Products and Production

As "reconstruction" limps forward, observers seem to be agreed that mass production is due for further modifications before it can return, if ever, to its former eminence in American business. Where, for example, a motor car manufacturer could ride along for years with a single chassis and a bare half dozen body designs in a single color, he is now forced to fortify himself annually with a multiplicity of models in colors of kaleidoscopic variety. All of which lays a heavy load on the shoulders of the chief engineer and his staff.

Gone, indeed, is the day when one can design a new product with easy confidence that the executive committee will okay requisitions for new tools and other additions to production facilities; gone too the day of easy model changes when a newly glorified hubcap and a modernistic color revision would justify an increased advertising appropriation. The model changes of the past two years are probably but a foretaste of the changes ahead of us. Heavy as the burden may prove to be, the engineer who aspires to leadership in his profession and security in his company will welcome the challenge.



Four steps in the redesign of a meter and the result

An Engineer Considers

ART IN ENGINEERING

COLIN K. LEE
General Engineer
Westinghouse Electric & Mfg. Co.

Mr. Lee finds that the rules and canons of art must not only be tolerated but recognized and applied. He lists six general rules that he has found most useful in his own work

▼

GOOD looks do not make machinery work better, any more than a clean white collar and a shoeshine make a man a better workman. But the designer who can spare time to consider the looks of a machine has no reason to worry about its performance.

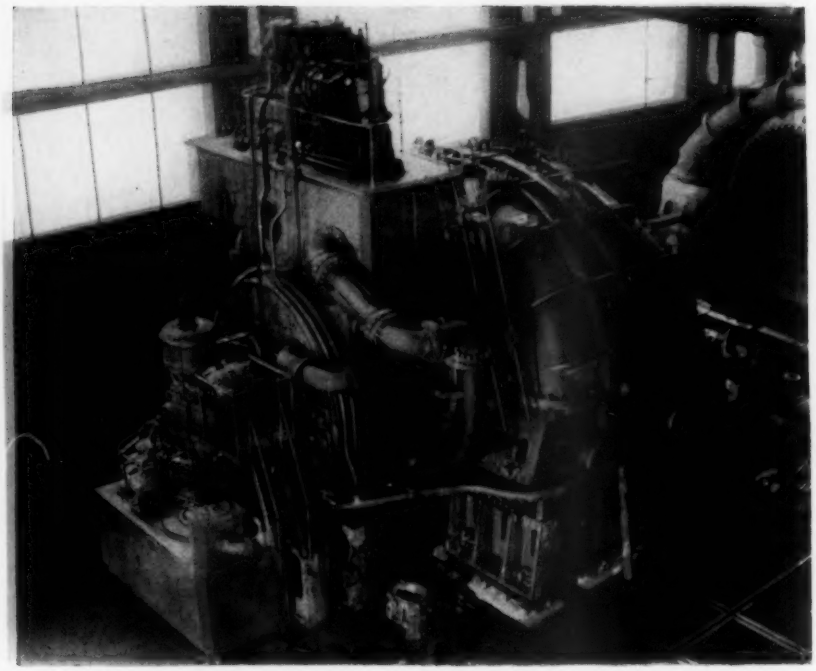
To meet this new requirement, it is natural for the engineer to call in the professional artist, but he may find himself unable even to understand the latter's language. The artist says familiar words — like rhythm, balance, opposition, roundness, honesty—but they do not make sense as the engineer understands their meaning.

Nevertheless, the artist's ideas are reasonable enough, once stripped of mysterious terminology. There are good rules, but every man has a right to his own idea of what is a good-looking machine. The final authority is not an academy of artists, but the man who is going to buy the product. The authority for these rules is that, in most cases, they have been found to hit the average taste.

These rules for good-looking machines, like the rules for the well-dressed man, aim generally at producing a quiet, unobtrusive effect. Sometimes they conflict among themselves, and there is one consideration that runs counter to nearly all of them. If a man, or a machine, wants to stand out in a crowd, it is a good thing to have some striking, even violent detail. In general, you can give a striking and individual look to any design by deliberately going contrary to one of the general rules. But you don't want to ignore all of them any more than you want to dress like a movie cowboy.

Some of these general rules, any one of which can sometimes be broken to good effect, are:

A Simple, Easily-Grasped Shape—The eye likes a simple form it can grasp without too much effort, especially if the shape is symmetrical about at least one axis. Most electric motors and generators are lucky that way; they are naturally circles



For many years engineers did not concern themselves with the appearance of steam turbines. All was well as long as they met their ratings

or cylinders. Radial airplane engines fall in the same class. The shape need not be circular, of course, to be symmetrical.

Shapes We Understand, and Shapes We Are Used To—A little girl of the 1880's, seeing her first locomotive, perceived only a confused ugly shape "as though there were shiny pots and pans tied all over it." Yet engineers have considered the locomotives of that period as among the most beautiful of machines, swift and graceful, whose every part expressed its function. To the same engineering eye, present-day big locomotives are ugly, because their outline is confused by innumerable gimmicks, feed-water heaters and the like, hung on in unexpected places, and such characteristic landmarks as smokestack, pilot, steam dome and bell have almost vanished.

Naval architects put dummy smokestacks on ships driven by diesel engines, to keep them from looking queer, but no doubt if they had been raised on motor-driven ships, the same men would think smokestacks very disfiguring.

Westinghouse Electric, a few years ago, began displacing castings with electric-welded structural steel, and immediately aroused objections of ugliness among its own engineers, whose eyes were accustomed to the tapers, curves and varying sections of the foundryman's art. Now that the novelty of welded fabrication has worn off, the new machines have good looks of their own. In time it may be the machines made of castings which will look odd.

Subordinate Lines Should Agree with the Dominant Shape—If the object is round, other lines should probably best be concentric with it. If straight lines are necessary against a circular or curved background, they should be radial, or more or less tangential; in any case be in some regular symmetrical arrangement. If the main shape of the thing is straight-sided, other straight lines should be parallel to these sides, or have some evident relation to them.

Attachments to the main shape should agree with it, and should not be too abrupt at the transition. This is the essence of the "streamlining" necessary in aircraft and recent fast ships. It is less necessary in other things, but always pleases the eye. An example arises, in electrical machinery, in the attachment of feet or brackets to the dominant circular form.

Function Should Determine Form—If the machine is designed with an eye single to the most efficient performance of its work, it will be beautiful without any further need to worry about it—an extension of the old rule for girls—"be good and you will be beautiful." It doesn't always work out, but is at least an ideal to work toward.

A familiar illustration is the design of the multi-polar dynamo by the Westinghouse engineers, Lamme and Schmid (1890). Previous dynamos had been notably queer-looking, with every designer feeling in honor bound that his machine should look nothing like any other. The dynamo evolved by Lamme and Schmid gained an immediate reputation for good looks. Widely copied, it established many salient features of such machinery to this day. Schmid explained the beauty of the design by saying that he had merely put the right amount of material where it was needed. It was not so simple as that—he had an artistic eye.

The "Golden Proportion"—It has been recognized for years that the best-looking rectangle has a certain fixed proportion; the short side is to the long side, as the long side is to the sum of the two sides. Greek temples were proportioned by that rule, and so is modern skilled typography. The progression of setbacks in modern skyscrapers often uses the rule, too. It is a good one to follow for any two unequal dimensions. In actual figures, the short side is 61.8 per cent of the long one. Any ratio close to this works fairly well. The next time you lay out a rectangle, or a line divided into two unequal parts, it will be interesting to try it.

Shapes Have Psychologic Effects—An object that is high and narrow may look dignified or stately or graceful, but is likely to look weak. On the other hand, things that are broad and low look strong, especially if they are broader at the base. Anything that is a solid mass to the eye looks stronger than something that the eye can see through, or that is seen to be made up of smaller parts. I have heard people say they would feel much safer in a little dirigible balloon than in an airplane, because it looked big and solid—yet the plane is probably safer.

More interesting than abstract principles are actual cases. Westing-

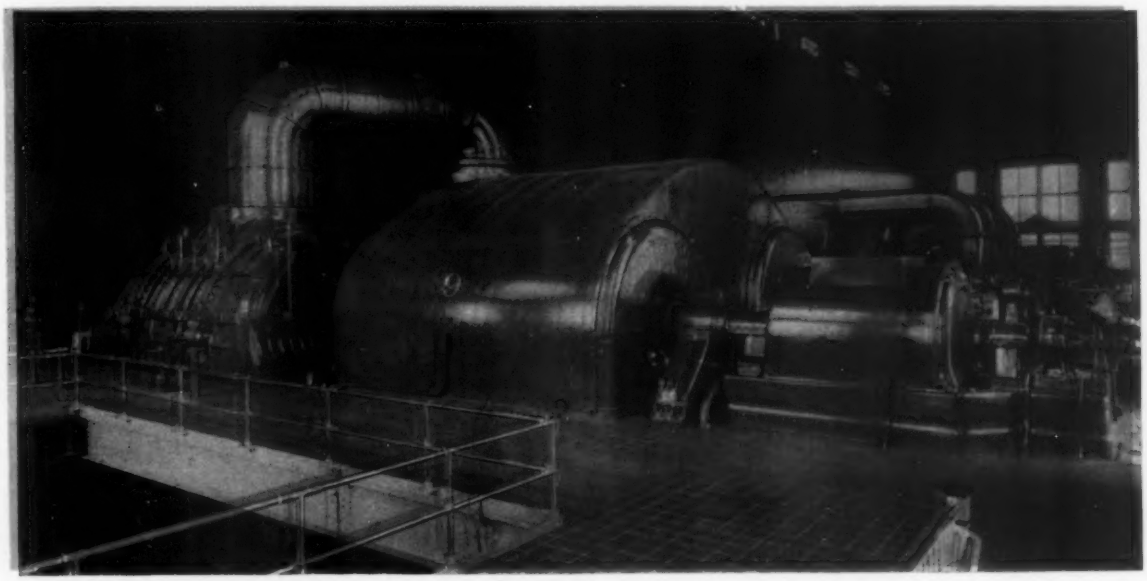
house has for several years employed a staff of artists, and conscious efforts toward pleasing design have affected steam turbines of a hundred thousand horsepower, and switch plates no bigger than a vest pocket.

Steam turbines, until recently, were clothed in an appalling maze of piping, governing devices, and mechanical linkages — necessary things which were draped about the main unit in any manner that seemed the easiest. Why not? Steam turbines are not bought out of a showcase; they are built to the order of highly technical men intent on fractions of a per cent in efficiency, heat balances, and all the mysteries of temperature and entropy. The public never sees them; and the operating men are not aesthetes. Nevertheless, it occurred to some Westinghouse man of sufficient authority that his turbines were "messy-looking," and at the next revision of design all these necessary adjuncts were planned and placed so as to be inconspicuous. Freed of a mass of incomprehensible detail, the natural form appeared definite and attractive, and this experiment in beauty seemed to have an actual effect on sales.

The electric generator, or dynamo, which is the invariable twin of a big powerhouse turbine, is already very good, considered as a shape—a long plain cylinder, the edges of its flat ends slightly rounded. A recent customer, wishing to ornament the plain sheet-steel sheathing, specified that the straps holding it on should be of polished stainless steel, reminiscent of the polished brass bands that are used to girdle old-fashioned locomotives. Turbine generators are usually sunk a little below floor level; on the side where it met the floor there would be a strip of stainless steel eight inches wide and twenty feet long. This is a formidable area of polished metal to be seen close up; the artist suggested it be toned down with a three-and-a-half inch lengthwise black streak down the center; the streak, he suggested, to be made by machining it; the engineers, better acquainted with shop practices, are going to shot-blast it instead.

Switchboard instruments, voltmeters and ammeters gave the artist a problem. Hitherto, they have been round—not a bad shape—but popular demand, and the general charm of novelty, called for a square instrument. Now the basis line of such instruments is a curve—the arc of the pointer's swing—on which the observer's attention is centered. The window opening, if rectangular, would contrast sharply with this curve. Better would be a curved window to agree with the curve of the pointer's swing. But the upper curve of the window must be kept well below the straight edge of the case; if too close, the conflict of the two lines will be conspicuous. Moreover, such intersections or near-intersections always have an attraction for the eye, and would focus attention on what is not, in this case, a significant point, the center of the top. The curved window is therefore lowered a safe distance from the top edge. This would be good, but there is a commercial consideration; there is lettering to be put on the dial, and to give room for this, the bottom of the window is made straight. This flat straight line right across the instrument's middle is, to the artist's eye, very "harsh and cruel," so he takes the curse off by adding a group of vertical lines on the case, which also agree well with the high narrow panel on which the meter is placed.

Artists are sometimes prone, like lawyers and others of the pharisaic professions, to insist upon the manner of the doing rather than upon getting the thing done. But, after all, what art in industry is shooting at is the customer's idea of beauty, and all rules are valuable only as assistance in holding the gun. Moreover, public taste is not a fixed bulls-eye, but a bird on the wing. There is no use in blackguarding the ornate taste of the nineties — forty years hence our present standards of beauty may seem as barbaric. Whatever the public taste be, however, it seems sure that as machinery closely approaches perfection, and competition becomes more severe, it will be increasingly essential to give all machinery the appeal of beauty.



But now appearance is considered secondary only to rating. Business-like power stations like Hell Gate are the result

Fig. 1—One form of metal-foil insulation, comprising a packet of foil sheets crumpled to form suitable air spaces. Three layers per inch are best

Heat Insulation With Metal Foil

J. L. GREGG
Battelle Memorial Institute

Extensive researches on the heat-insulating properties of thin aluminum foils have established several types of highly efficient foil insulations. Relative merits of the various constructions are explained by the author, who supervised the work

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ON FIRST thought the use of metals as heat insulators appears to be absurd, for metals have a thermal conductivity of about a thousand times that of well-known thermal insulators such as cork. Nevertheless, by using a small amount of metal and a larger amount of air, one can produce very light and efficient thermal insulators. The results of some studies of the properties of metal-foil insulators made at the Battelle Memorial Institute for the Reynolds Metals Company are briefly set forth below, some of this work having been described in more detail in a paper given at the January meeting of the American Society of Refrigerating Engineers.

Two general methods for using foil to restrict the flow of heat have been proposed. In one, flat sheets of foil are held apart by suitable spacers; in the other, foil sheets are slightly crumpled and stacked one on top of the other to form irregular air layers. Foil suitable for the latter type of insulation has been marketed under the trade name "Alfol," and has apparently been extensively used abroad. In either type of insulator the foil serves a dual purpose in minimizing the transfer of heat through air spaces, for it decreases the amount of heat transferred by convection by subdividing the space and likewise decreases the amount of heat transferred by radiation due to the high reflectivity of foil surface.

The use of air layers for restricting the flow of heat has been decried by many engineers, for even though the actual conductivity of air is below that of any commercial insulating materials, heat may be transferred by actual movement of the air, i.e., convection, and by radiation. If, however, the air space is subdivided to form layers less than an inch thick, the quantity of heat transferred by convection may be greatly decreased; if in addition the boundaries of the air layers consist of a material having a high reflectivity, the quantity of heat transferred by radiation can be rendered almost negligible. Therefore, a multiplicity of thin air spaces bounded by bright metal makes an extremely effective insulator.

With respect to reflectivity for low temperature radiation, materials may be divided into two classes: (1) bright metals, having a very high reflectivity; (2) other materials, whose reflectivity is quite low. For low-temperature radiation the reflectivity of bright metals is approximately 95 per cent, but most metals tarnish rapidly and their reflectivity decreases rapidly with time. Aluminum, however, on exposure to the atmosphere, becomes coated with a thin and adherent oxide coating which protects it from further attack, and which does not appreciably affect its reflectivity. A sample of aluminum exposed for about a year and a half on a roof at Columbus, Ohio, was found to have suffered practically no measurable change in that regard. The ideal material for utilizing the low thermal conductivity of air, therefore, appears to be aluminum, for in addition to the permanence of its bright surface, it can be readily rolled into foil and has a low specific gravity. Aluminum is regularly produced in thicknesses down to 0.00025

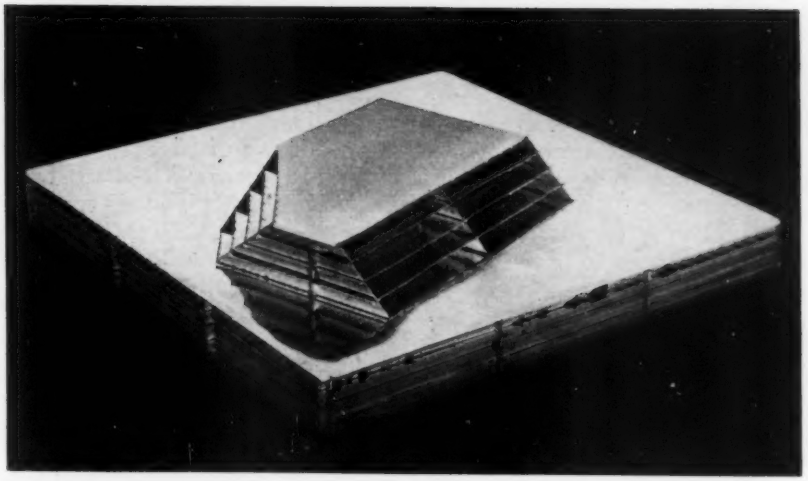

Fig. 2—Foil or foil-covered paper is spaced by thin wooden lattice work to form low-conductivity insulation. Sheets spaced ½ in. are most satisfactory

in. (approximately 45,000 sq.in. per lb.)

Thermal conductivity is defined as the quantity of heat that will flow through unit area in unit time for unit temperature drop in a direction parallel to the flow of heat. In American engineering practice these units are selected so that the conductivity represents the quantity of heat expressed in B.t.u. per sq.ft. that flows through the material per hour when the temperature drop is one deg. F. per in. of thickness; these are the units in which conductivity is expressed below.

The values of conductivity and unit weight of space filled with crumpled foil shown in Table I indicate quite definitely that extremely light and effective insulators can be formed from thin foil. The best insulation properties for this type, apparently result when three layers per inch of the thinner crumpled foil are used. These and other tests reported here were made at an average temperature of approximately 100 deg. F.; at lower temperatures the conductivity would be less, and at higher temperatures greater. For purposes of comparing the properties of foil insulators with the properties of better known insulators, the values of conductivity and unit weight of some miscellaneous materials as measured at Battelle Memorial Institute are given in Table II. As may be observed by comparing Tables I and II, insulators made with crumpled foil have only a small fraction of the weight of the best non-metallic insulators.

Still better insulating values can be obtained with foil if plain sheets are spaced at regular intervals. Difficulties in forming this type of insulting units arise from the lack of stiffness of the foil. But after experimenting with many types of spacers, we found that rigid units could be built by spacing foil-covered paper or foil alone with a lattice work of thin wood. This type of insulating unit is shown in Fig. 2. In order to produce a unit of this type, it is necessary to use surface sheets consisting of foil-covered paper or cardboard, but the inside sheets may be unmounted foil. The spacers are held to the plates by means of an adhesive. Conductivity values obtained on units of the type pictured in Fig. 2, and having air layers of various thicknesses, are shown in Table III, and the conductivity as a function of the air-layer thickness is plotted in Fig. 3. From these data the most satisfactory insulator would probably be that in which the foil sheets are spaced at a distance of ½ in.

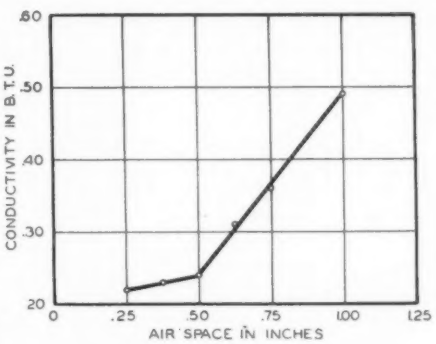

Fig. 3—Conductivity of rigid insulating units illustrated in Fig. 2

TABLE III

Conductivity and Weight of Units Made by Spacing Foil-Covered Sheets with Wooden Lattice Work

Thickness of air layer, in.	Conductivity, B.t.u.	Weight, lb. per cu.ft.
0.25	0.22	4.1
0.37	0.23	3.1
0.5	0.24	2.8
0.67	0.32	2.5
0.75	0.36	2.1
1.0	0.48	2.1

TABLE I

Conductivity and Weight of Crumpled Foil Stacked in Layers

Layers per in.	0.00023-in. foil: Conductivity, B.t.u.	0.00023-in. foil: Weight, lb. per cu.ft.	0.00035-in. foil: Conductivity, B.t.u.	0.00035-in. foil: Weight, lb. per cu.ft.
1	0.42	0.038	0.41	0.058
2	0.36	0.077	0.37	0.115
3	0.32	0.115	0.37	0.176
4	0.34	0.154	0.35	0.230
5	0.37	0.192	0.35	0.288
6	....	.....	0.35	0.346
7	....	.....	0.37	0.403

TABLE II

Conductivity and Weight of Miscellaneous Materials

	Conductivity, B.t.u.	Weight, lb. per cu.ft.
Standard corrugated paper (no liner)	0.38	4.6
Same with 0.001-inch aluminum foil between layers	0.34	5.8
Standard single lined corrugated paper	0.35	7.5
Double corrugated cardboard used around solid CO_2	0.38	7.5
Tippican cardboard (parallel to grain)	1.35	30.0
Chip board cardboard (parallel to grain)	1.73	30.0
Masonite	0.39	19.5
Celotex	0.37	16.7
Hard sponge rubber	0.43	30.9
Standard cork board	0.32	11.4
Rock cork	0.33	16.3
White pine (perpendicular to grain)	0.70	24.4
Yellow poplar (perpendicular to grain)	0.71	22.5

The outstanding property of crumpled foil insulation is its extremely low weight per unit volume. As it also offers a resistance to heat flow equivalent to the more generally used insulators, it should find important applications where weight is important. A promising field appears to be in the insulation of shipping containers, cars, trucks, ships, and, in general, anything that must be moved from place to place. It has apparently been used extensively abroad for pipe insulation, its only undesirable feature appearing to be the time required for installation. When exceptionally good insulating properties are desired and where a larger number of sheets of uniform dimensions can be used, an insulator of the rigid type appears to be appropriate. Such would be unexcelled for use in household refrigerators. Like any material used in refrigerating practice, foil insulation should be used in such a manner as to prevent condensation of moisture on the parts of the insulating unit that are below the dew point.

Another method, which has apparently not been used, but which is particularly appealing in its simplicity, effectiveness and economy, is to decrease the heat transmission through the air layers by the use of a shiny foil. The foil in this case should preferably be mounted on a heavy paper. Two simple methods for using the foil covered sheet are apparent: (1) Tack the foil-covered sheet on one side of the studding in such a manner that one boundary of the air layer will be foil; (2) Insert the foil sheet to divide the original space into two spaces, each one-half the thickness of the original space.

Testing Foil Insulation

In order to determine the effectiveness of foil-covered paper used in the manner described above, a special apparatus for measuring the heat flow through walls was constructed. This equipment was modeled after one used successfully by the Bureau of Standards. It consists of two boxes placed on either side of the sample with the necessary equipment in each box for obtaining a predetermined temperature and fans for circulating the air. The surface of the sample used was 3x9 ft., and the temperature of the air on one side of the wall was maintained at 50 deg. F., while the other side was 80 deg. F. The rate of heat flow through the sample was determined by means of a heat-flow meter, and the temperatures of the opposite sides of the walls were recorded. Within limits, the rate of heat flow through the wall is proportional to the temperature drop through the wall, and the quantity of heat expressed as B.t.u. that flows through each sq.ft. per hr. per deg. F. drop across the sample is called conductance. The apparent conductivity is equal to the conductance multiplied by the thickness of the sample, in our case 4.84 in.

In order to test a rather general type of wall construction, the samples sketched in Fig. 4 were prepared. These samples are simply wall sections made with 2x4 wooden members

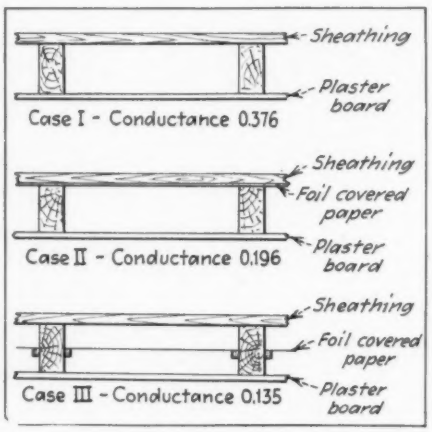

Fig. 4—Effect of one sheet of foil-covered paper in decreasing heat flow through walls of refrigerator cars, boxes, and similar structures

arranged to form air layers $3\frac{5}{8}$ in. thick—the nominal 4-in. dimension of the lumber. In Case 1, no foil is used; in Case 2, the sample contains a layer of foil adjacent to the studding and forming one surface of the air layer, while in Case 3, the air layer is subdivided by foil-covered paper. As is evident from the values for conductance shown in the sketch, the rate of heat flow is halved by using foil in Case 2, and is reduced to practically one-third of the flow through the uninsulated wall by use of the foil as in Case 3. Simple calculations based on these values demonstrate that the use of foil-covered paper as in Case 2 is approximately equivalent to adding a $\frac{3}{4}$-in. layer of cork to the wall; using it as in Case 3, it is equivalent to using a $1\frac{1}{2}$-in. layer of cork. The arrangement described as Case 3 has a resistance to heat flow equal to 80 per cent of that through the wall of a mechanical refrigerator of the more expensive type having a 3-in. layer of good but expensive insulation. Such a comparison serves to indicate that many structures can be insulated to a good degree of effectiveness simply by using a layer of foil-covered paper in conjunction with an air space.

In all design problems where heat flow must be baffled, foil insulation deserves consideration, for it is a decidedly promising addition to the group of insulating materials now available.

Effect of Variable Friction in Differential Brakes

(Continued from page 197)

Using a coefficient of friction of 0.35, and for a maximum available pull P equal to 200 lb. we have from Equation (4):

$$Pc = 1.30\,(5000b - 5000 \times 2\tfrac{1}{4}) - 5000b$$

Assuming b to be 13 in. long:

$$Pc = 3300 \text{ in. lb.} \qquad c = 16.5 \text{ in.}$$

Now having determined the linkage for normal operation of this brake, let us vary the coefficient of friction from a minimum of 0.25 to a maximum of 0.50 to see what happens to the force P. We will also compare the live end load T_2 necessary to engage the brake, with the force we actually receive in the live end from the dead end load. From these values Fig. 3 was plotted.

Analyzing these curves we find that as u increases, the curve *2* approaches curve *1*. Curve *3* drops quite rapidly until at the point where $u = 0.395$ the value P is equal to zero and the force necessary to set the brake is exactly equal to the force given to the live end by the dead end load through the linkage a and b. If the coefficient of friction of our lining in this brake should increase from its designed value of 0.35 to 0.395, a very slight increase, the brake would be self locking and control would be lost.

If now in our original design we had chosen u at 0.50 purposely, to guard against its becoming self-locking, then the force P with a decrease in the value of u would become exceedingly large, and with our available P at 200 lb. we would be unable to set the brake.

As was pointed out before, the only way through which these serious features can be overcome is by the use of a linkage arranged so as to give a variable mechanical advantage.

Rational Design of Shafts

EMORY KEMLER
Gulf Research Laboratory

A summary of design practice for determining shaft sizes, including considerations such as standard shafting sizes, stress concentration, fatigue, effect of keyways, operating conditions, working stresses. The Reference Book Sheet on pages 227 and 228 of this number forms a part of this article, and eliminates the tedious arithmetical work in the solution of combined stress problems in the design of shafts for various types of loading

▲

THERE are many general considerations dictated by standard practice and application that affect the design of shafts. The first is the standard size of shafting used. For ordinary cold-rolled transmission shafting the standard sizes increase by $\frac{1}{4}$ in. intervals up to $5\frac{15}{16}$ in. diameter. Machinery shafts can be obtained in sizes increasing by $\frac{1}{16}$ in. up to $2\frac{1}{2}$ in. diameter and then by $\frac{1}{8}$ in. increments up to 4 in. diameter. In power transmission work it is best to use the regular transmission shafting sizes in order to be able to get replacements such as bearings, pulleys, and similar units more quickly.

Stress concentration and fatigue is an important consideration when the shaft diameter varies. At sections where the diameter changes abruptly, large fillets should be used if possible. If a square shoulder is necessary, some such arrangement as shown in Fig. 1 is often used, making it possible to obtain large fillets. Figs. 3 and 4 show the stress concentration factors for bending and torsion, the figures indicating how many times greater the stress at the root of the fillet is than the average or theoretical stress based on ordinary elementary methods of calculation. Stress concentration is of first importance in connection with members subjected to alternating stresses.

Editors Note: — The article, "Stresses in Fillets," by E. F. Garner, which appeared on page 259 of the June 1931 number of *Product Engineering* gives further detailed information on this subject.

When a rotating shaft is subjected to a bending load it must be designed to take care of the fatigue. As shown in Fig. 2 at *A* the fibres *a-b* at the top of the shaft are in compression. When the shaft has turned through 180 deg. as shown at *B*, these same fibres *a-b* are at the bottom and are put in tension. Such reversal of stresses will cause a member to fail at stresses considerably smaller than the ultimate strength as obtained in static tests, and therefore this factor must be given consideration.

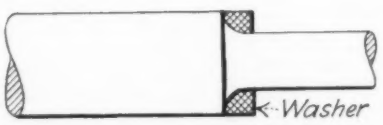

Fig. 1—Where a square shoulder is required, a collar can be put over a large fillet

Experiments conducted by Prof. H. F. Moore at the University of Illinois showed that the static and torsional strength of a shaft with a keyway is reduced by about 15 per cent below that of a plain shaft. Other tests have shown that 0.65 carbon steel shafting had the elastic strength reduced by 23 per cent and the endurance limit reduced by 21 per cent. The A.S.M.E. shafting code recommends 25 per cent reduction of the working stress when a keyway is put in the shaft.

In some cases it is necessary to calculate the size of the shaft on the basis of deflection as well as strength. Thus, when the clearances are small or when a long sleeve clutch is used on the shaft, or long bearings are used, excessive deflections would cause trouble. In most cases, except the very simple ones, it is necessary to resort to graphical or energy methods to determine the deflections.

To some extent, the type of drive affects the factors of safety to be selected. A belt drive, for instance, acts as a shock absorber. The extent to which shocks are thus absorbed depends to some extent on the severeness of the shock and the properties and length of the belt. On the other hand, a gear or chain drive, not being so flexible, will transmit the shock with greater severity.

In high-speed shafting such factors as unbalanced weight and long keyways result in considerable vibration and increased stress in the shaft. Long keyways cause vibration because the moment of inertia varies in the perpendicular planes, which results in a variation in the deflection during rotation. If the speed is high or of the right frequency, this may cause considerable vibration. At the critical speed, the vibrations might be disastrous.

The selection of the factor of safety is the most difficult problem. Values to be used depend upon the type of load, the characteristics of the material, the variations in load, the endurance limit of the steel and the reliability required. The code of the A.S.M.E. on the "Design of Transmission Shafting" was formulated after years of study and conference with those working on the design of

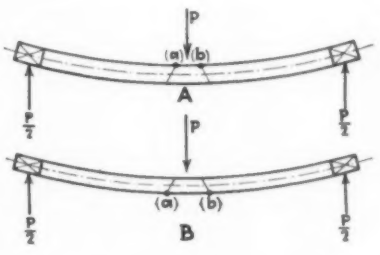

Fig. 2—After rotating through 180 deg. the fibre a-b, which has been in compression as shown at *A*, is put under tension, as at *B*

shafting and after submitting the preliminary drafts for criticism and comment. This code, then, represents and summarizes rational design practice for determining shafting sizes.

The committee, after studying the experimental data available, decided that the failure of steel in a shaft takes place in shear. The code is, therefore, based on the maximum-shear theory, which is the conservative basis for the design of shafting.

The A.S.M.E. code recommends a maximum permissible tensile or compressive working stress of 16,000 lb. per sq.in. for ordinary commercial steel shafting when no allowance is to be made for keyways. With allowance for keyways this figure should be reduced to 12,000 lb. per sq.in. The maximum permissible shearing stress without allowance for keyways is 8,000 lb. per sq.in. and 6,000 lb. per sq.in. with allowance for keyways. These stresses are to be applied only in the case of static loads.

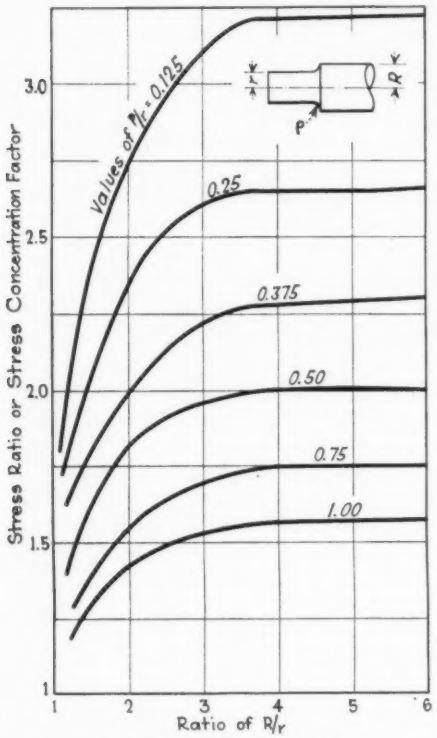

Fig. 3—Ratio of concentrated stress to normal tension, compression, or transverse stress

If the steel is bought on specification, the code recommends that the working stress in tension or compression should not exceed 60 per cent of the elastic limit in tension and not more than 36 per cent of the ultimate strength. The torsional stress should never exceed 30 per cent of elastic limit in tension or 18 per cent of the ultimate strength. Where failure is to be particularly guarded against, a reduction of 25 per cent in the working stress is recommended.

Factors of safety as recommended by the A.S.M.E. code are based on the ultimate strength, since in transmission design it is not so important to design against elastic failure. The factor of safety may be applied by either decreasing the working stress or by increasing the loads which would in turn increase the bending moment and torque. Table I gives these factors for various types of loading, closely following the specifications of the A.S.M.E. code. In Table II is given the factors of safety based on the ultimate strength with allowance for keyways.

It will be noted that the torsional factor of safety is in general less than that in bending, except in the case of stationary shafts. This comes about because the material is subjected to a complete reversal of bending stress each revolution, whereas the torsional stress usually varies only in magnitude. Even if the torsional stress does change direction, this takes place only a relatively few number of times as compared to the revolutions of the shaft. In stationary shafting there is no reversal of stress and consequently the same factor is used for both bending and torsional stresses.

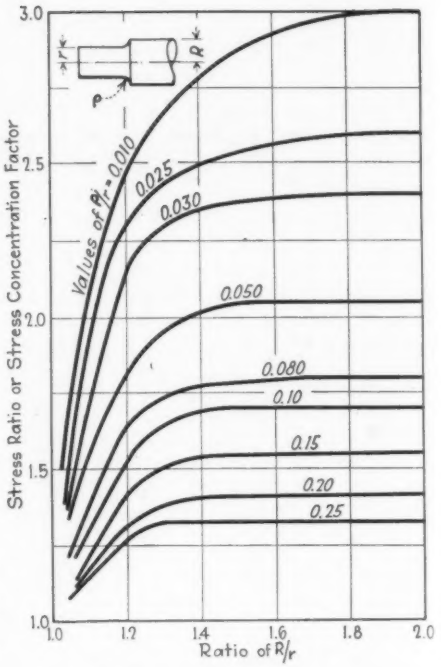

Fig. 4—Ratio of concentrated stress to normal torsional stress

The derivation of the formulas for simple torsion, bending, and combined bending and torsion can be found in most textbooks on strength of materials, and only the equations in the most usable form will be given here.

Table I

Shock and Fatigue Factors

	—Multiplication Factor— For Torque	For Bending
ROTATING SHAFT	K_t	K_b
A. Steady or gradually applied loads	1.0	1.5
B. Suddenly applied loads — minor shocks	1.5	2.0
C. Suddenly applied loads — heavy shocks	2.0	2.5
D. Suddenly applied loads — with heavy shocks; severe operating conditions, and high reliability required	2.5	3.0
STATIONARY SHAFT		
E. Steady or gradually applied load	1.0	1.0
F. Suddenly applied loads — minor shocks	1.5	1.5
G. Suddenly applied loads — heavy shocks	2.0	2.0

Table II

Factors of Safety for Various Types of Loading

(Based on ultimate strength with allowance for keyways)

	Torsion	Bending
Static loads	4	4
ROTATING SHAFTS		
A. Steady or gradually applied loads	4	6
B. Suddenly applied loads — minor shocks	6	8
C. Suddenly applied loads — heavy shocks	8	10
D. Suddenly applied loads — heavy shocks; severe operating conditions and high reliability required	10	12
STATIONARY SHAFTS		
E. Steady or gradually applied loads	4	4
F. Suddenly applied loads — minor shocks	6	6
G. Suddenly applied loads — heavy shocks	8	8

The following symbols will be used:

S_s = Base shearing working stress, lb. per sq.in.
S_t = Base tensile working stress, lb. per sq.in.
d = Diameter of shaft, inches.
r = Radius of shaft, inches.
M = Bending moment, in.-lb.
T = Torque, in.-lb.
J = Polar moment of inertia, in.^{4}
I = Plane moment of inertia.
K_t = Torsional multiplication factor to take care of various loading conditions.
K_b = Bending multiplication factor.
N = r.p.m.
$hp.$ = horsepower.

We have from strength of materials that $K_tT = \frac{S_sJ}{r}$ for a circular shaft.

This reduces to:

$$d = \sqrt[3]{\frac{16\ K_tT}{S_s}}$$

Expressed in terms of horsepower:

$$d = \sqrt[3]{\frac{321{,}000\ K_thp.}{NS_s}}$$

For simple bending of a circular shaft:

$$S_t = \frac{K_b\,Mr}{I}$$

$$d = \sqrt[3]{\frac{32\ K_bM}{\pi S_t}}$$

For combined bending and torsion:

$$d = \sqrt[3]{\frac{16}{\pi\ S_s}\ \sqrt{(K_bM)^2 + (K_tT)^2}}$$

The charts for finding shaft sizes (see pages 227 and 228) are self-explanatory. They can be used for finding the sizes of circular shafting subjected to pure torsion, bending, or combined torsion and bending. Similarly, these charts offer an easy solution of combined stress problems in the design of shafting.

Cam Mechanism for an Adjustable Dwell

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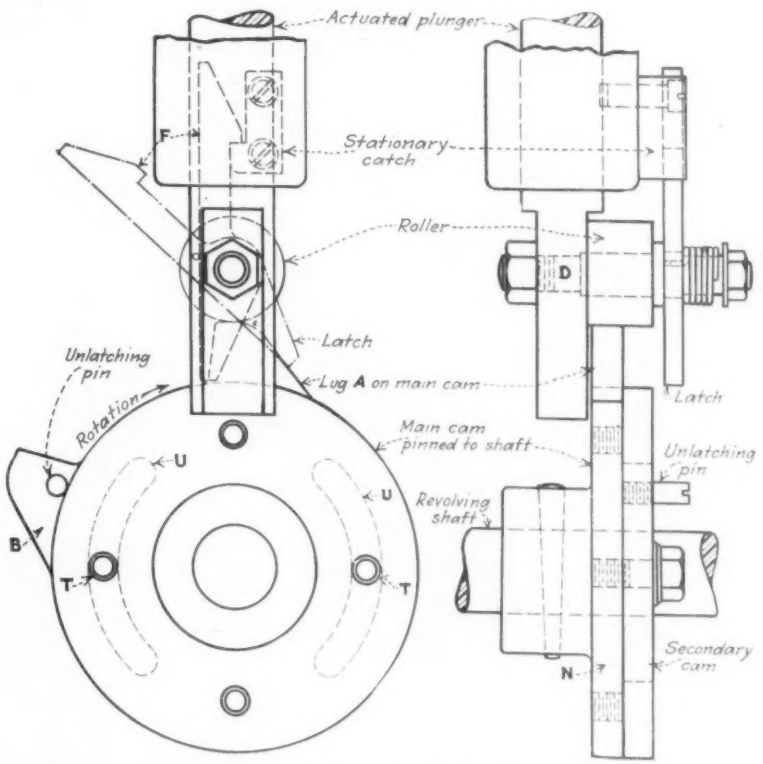
Designing Engineer,
Package Machinery Company

Occasionally in automatic machines it is necessary to operate a movement intermittently with a variable period of dwell. To accomplish this an adjustable cam of the type shown here can be used, wherein the plunger is pushed up intermittently. In this construction a latch locks the plunger in the up position. After holding the plunger for the desired period of time, the latch is released and the cam allows the plunger to return to its starting point.

Referring to the illustration, the round plunger operates up and down in its housing. At the lower end of the plunger is a roller mounted on a shouldered stud, on which is also mounted a latch as shown in the figure. The torsion spring exerts a pull on the latch tending to rotate it clockwise. If permitted by the cam to do so, the latch hooks itself on the stationary catch, as shown by the dotted lines. Part of the time during each cycle of the machine operation, the latch is swung by the cam clear of the catch and assumes the position indicated by the dot and dash lines. This position is shown exaggerated, for in actual practice the latch only swings a little more than enough to unlatch. To cause it to unhook, the unlatching pin in the rotating cam pushes the lower end of the latch.

The operating cam proper is made in two parts. One is the main cam pinned to the revolving shaft and having the lug A. As the cam revolves this lug engages with the roller, forcing the plunger up into the position shown and allowing the latch to hook over the catch, thereby holding the plunger in the up position. The plunger then remains in the latched position, until the unlatching pin in lug B strikes against the tail of the latch and swings it over to the unlatched position. The roller then rides on the profile of lug B, the plunger dropping as the roller rides down on the lug B, in the usual manner provided for in cam constructions. Lug B is part of the secondary plate cam indicated in the right hand view. This secondary cam is attached to the main cams by screws T passing through the elongated slots U in the secondary plate cam. This cam can thus be swiveled about the operating shaft as a center, thus varying the distance between lugs A and B and thereby varying the number of degrees through which the latch holds the plunger in the up position.

In practice it is advisable to have lug B raise plunger slightly so that the latch will be released when there is no load on it. The action of this mechanism is identical with that obtained by the use of an ordinary cam except that the dwell which takes place between the rise and return of the plunger can be varied.



The circular slots in the cam plate permit adjustment of the lug B, thereby varying the time that the plunger is held in the latched position

Roller Clutches for F

F. A. FIRNHABER
Machine Designer, Landis Machine Company

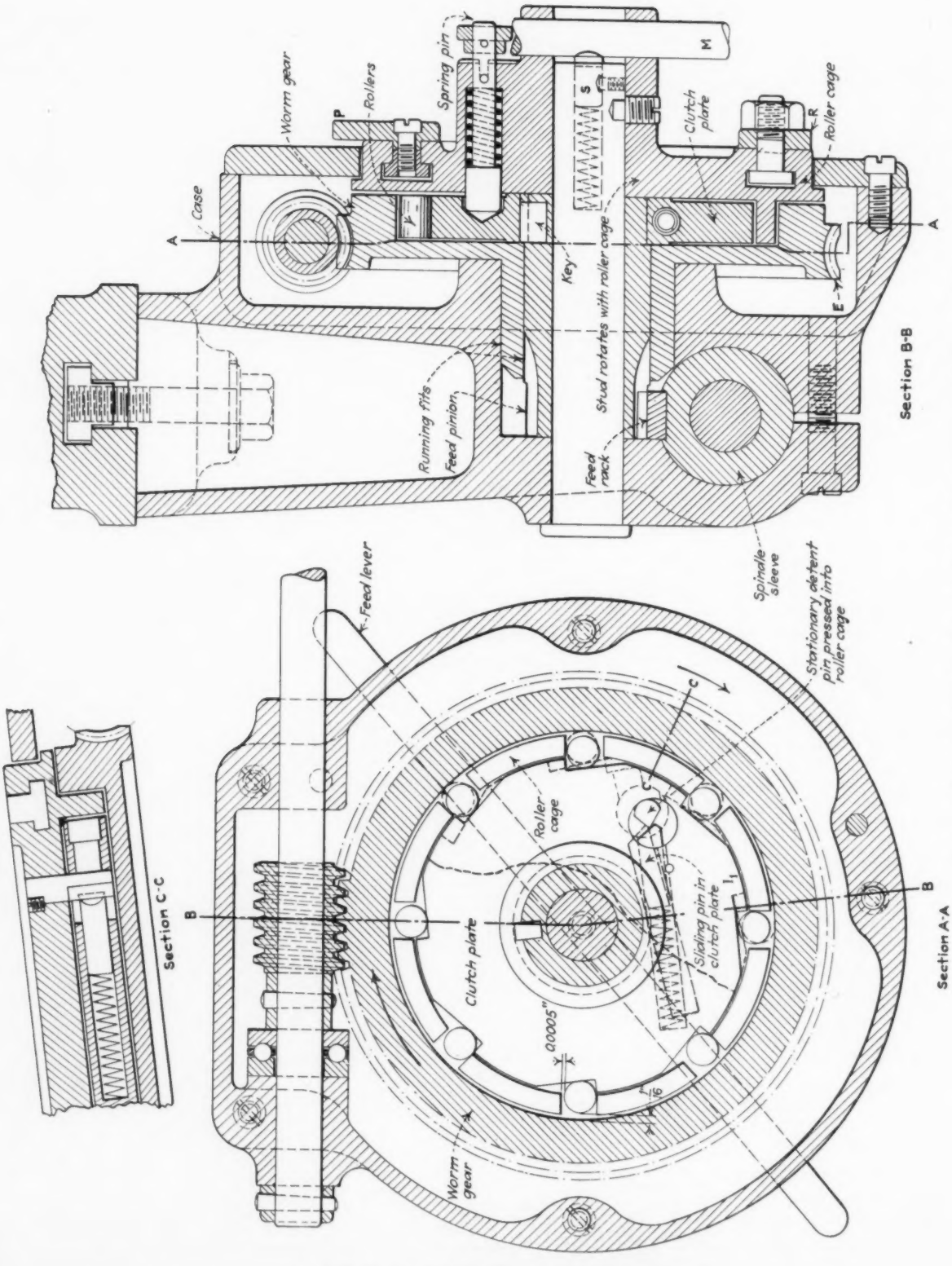


Fig. 1—Details of the design of roller clutch for feeding a drill press spindle. The section at the left shows by dotted lines the detents and rollers in the clutched position

Feed Mechanisms

Some uses for roller-clutches:

1. Over-running clutches as in automobiles.
2. To lock against opposite rotation, as in inclined belt conveyors and bucket elevators
3. To permit reversal of rotation of one member with uni-directional rotation of the other member, as in the drill-feed mechanism described here
4. As a substitute for the ratchet and pawl mechanism

IT IS perhaps more interesting than significant that the over-running roller clutch, made famous by automobile free wheeling, dates back to Dr. Rudolph Otto, pioneer in internal combustion engines. In fact, one of his first gas engines, on exhibit at Lehigh University, has such a clutch in combination with a pinion and a rack on the piston rod, to take the place of a crank. A later design is the Horton type roller or ball friction clutch, and it is this design, modified to suit the power requirements, that is now used in automobiles.

Such a clutch is also used in jig work, in some types of arbors, in place of ratchets where a pawl is not desired, in one-revolution clutches for press work and in various forms of feeding mechanisms. In the accompanying illustration is shown an application to a drill press feed.

This particular clutch has been in use for the past eight years, giving excellent service. In addition it has two safety features of merit. One of these prevents accidental engagement or disengagement, and the other locks the mechanism in a neutral position, making it ineffective for power feeding.

The purpose of the mechanism is to actuate the spindle sleeve of a drill press. On the sleeve is fastened the feed rack which engages with the feed pinion keyed to the clutch plate. The pinion and clutch plate assembly is free to rotate on the central stud, to which is keyed the roller cage. The extended hub of the worm gear is bored to have a running fit on the pinion sleeve, while the outside of the extended hub is turned for a running fit in the bore of the case.

Owing to the light duty that this clutch performs, the rollers are made of No. 1015 or 1120 S.A.E. steel, and are not heat-treated. The gear, clutch, and roller cage are of cast iron. For heavier service, a hardened ring may be pressed into the worm gear and the clutch plate may be made of a low-carbon steel, carburized and hardened. Distortion will not take place with this heat-treatment. The rollers could be made of drill rod, hardened and polished.

The adjustable feed lever, made of cold-rolled steel, passes through the hub of the roller cage, which is fixed by a setscrew to the central stud. The feed lever is held in any desired extended position by the spring and plunger arrangment *S*. A dog pointed screw fitting in an enlarged hole in the plunger keeps the plunger from shooting out if the hand lever is removed entirely.

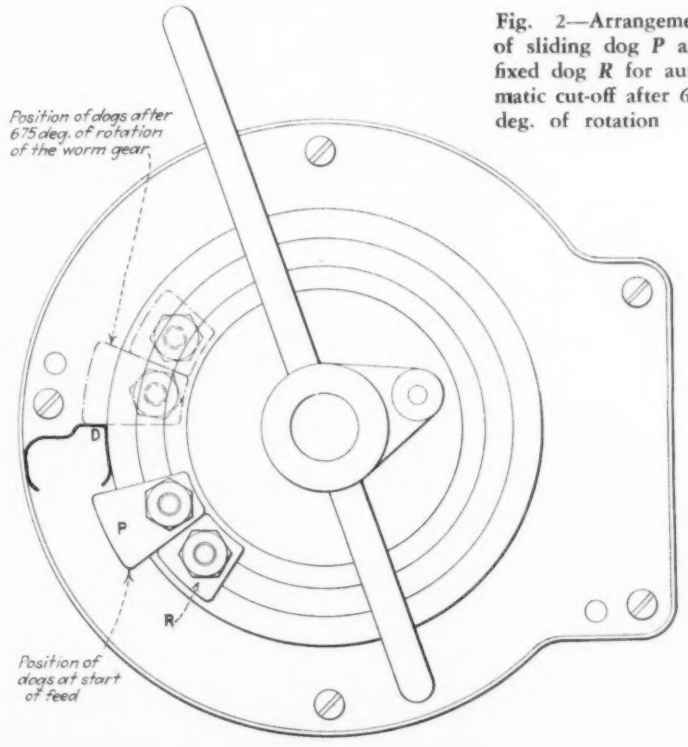


Fig. 2—Arrangement of sliding dog *P* and fixed dog *R* for automatic cut-off after 675 deg. of rotation

As can be seen from the illustrations, pulling the feed lever in a clockwise direction turns the roller cage, thus forcing the rollers up the inclined surfaces of the clutch plate and thereby contacting with the inside surface of the recessed worm gear. While this engagement makes a driving angle it is not necessarily a sticking angle. The mathematics of this angle are duly explained in Halsey's Handbook, which takes into consideration the problem of lubrication also. However, the backward or releasing pressure must not be too great.

In order to insure positive engagement, a lock was devised consisting of a spring-backed sliding pin mounted in the clutch plate engaging with a stationary detent pin mounted in the roller cage. Fig. 1 shows the unclutched position with the rollers idle and the manner in which the detents maintain this relative position. In the front section view is shown by dotted lines the clutched position with the rollers in engagement, the stationary detent having passed over the point of the sliding detent into the locked position. This design compensates for any wear on the roller wedging contact surfaces.

When disengagement takes place, and the flat points of the detents pass each other, and the spring snaps the roller cage back quickly on account of the angular sides of the detents. To disengage manually, it is only necessary to give the feed lever a slight tap, thereby rotating the roller cage

counter-clockwise, forcing the rollers into a neutral position.

To disengage automatically, a novel arrangement, as shown in Fig. 2, was designed. As the travel of the rack sleeve and consequently the spindle, is limited by the diameter of the pinion, and is just less than the pitch circumference of the pinion, a pair of dogs are placed in the position as shown in the figure. These permit approximately 675 deg. of rotation of the pinion and knock off or disengage the power feed automatically. In order to make possible 675 deg. of rotation, a T-slot is milled in the roller cage and the sliding dog *P* is free to slide in this slot while the adjustable dog *R* is clamped in place. It will be seen that dog *P* must do the disengaging by contacting with the boss *D*, cast integral with the cover of the case. The dog *P*, however, must be backed up by the dog *R* to become effective. Therefore, as the clamped dog *R* must make one complete revolution before it starts pushing the sliding dog, the total revolution of the feed pinion will be 720 deg., less the angle subtended by the boss *D*. Unlike the manual operation, the roller cage is momentarily held from rotating and the clutch rotates until the detents pass each other.

When it is desired to make the clutch ineffective and to feed by hand, the knurled head spring-pin is placed in the position shown, locking the roller cage and the clutch plate in the neutral position. To disconnect, the plunger is pulled out by means of the knurled knob and rotated 90 deg., in which position the pin drops into the shallow slot, thus locking the plunger out of engagement.

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Coming in June!

All who read "Vital Variables in Steel Stampings" in the April *P.E.* will be interested to hear that J. K. Olsen, chief draftsman, Stewart-Warner Corporation, has completed an article for the June number which will give further practical, concrete data on designing metal stampings. In the same issue will begin the promised series on Electrical Control Equipment.

▲ ▲

COMMUNICATION AND COMMENT

Results of Tests on Wick Oilers

JAMES I. CLOWER

The article, "Journal Friction with Boundary Lubrication," which appeared in the March number of *Product Engineering*, was of much interest to me, especially the part pertaining to wick-feed oilers. Some time ago I conducted a series of experiments to determine the effects of certain conditions upon the rate of feed of wick-feed oilers. The results shown in the following table were obtained by use of the apparatus shown in Fig. 1.

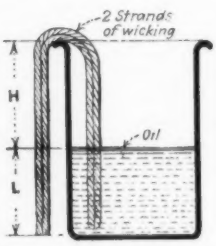


Fig. 1—Simple test apparatus for investigating the conditions affecting the rate of feed of wick-feed oilers

As shown in the table, when *L* was less than ¼ in. no flow of oil occurred, but when *L* was ¼ in. the pressure was sufficient to break a drop loose every 40 seconds. Increasing *L* increased the rate of feed until the difference became approximately 2 in. Further increasing *L* had but very little effect upon the rate of feed. These results clearly indicate that in order to obtain a uniform rate of feed, the discharge end of the wick should be, if possible, about 2 in. below the lowest oil level.

Often the wick-feed oiler is built integral with the bearing cap and the height from the top of the shaft to the bottom of the oiler is not as much as 2 in. In such cases, the wick should be placed in contact with the shaft, which will remove the oil from the end of the wick, thereby producing the same effect as if the wick were longer.

As explained above, the effect of dimension *L* is negligible when the discharge end of the wick is 2 in. or more below the oil level. In another series of tests *L* was made 2 in. and the oil level *H* was varied. The following results were obtained:

The rate of flow decreased very rapidly as *H* was increased above 2 in. These results show that the oil level is very important, as the variation in the rate of feed is 650 per cent cent for a drop of 2 inches.

As indicated by the results in the following table, the rate of feed is not quite proportional to the number of strands in the wick, being slightly greater. This is due, no doubt, to the capillary action between the different strands. However, for all practical purposes, the rate of feed may be assumed to be proportional to the number of strands, as shown here.

It is important that the strands be laid parallel and not twisted. The rate of feed for three strands slightly twisted was approximately the same as for a single strand, while six

Height "L" in Inches	Time Between Drops in Seconds
4	4.0
3	4.0
2	4.1
1½	4.5
1	7.3
¾	10.0
½	17.5
¼	40.0
Under ¼	No flow

Height "H" in Inches	Time Between Drops in Seconds
⅛	10.0
¼	11.5
½	15.0
¾	19.0
1	24.0
1½	36.0
2	65.0

Number of Strands	Comparative Rate of Feed
1	1
2	2.2
3	3.3
6	6.4

strands also slight twisted gave about the same rate of feed as two parallel strands. From these results and others it appears that a slight twisting of the strands reduces the rate of feed by about two-thirds.

Without going into the details of the physical properties of the oil used and the method employed, it is enough to point out that the rate of feed is approximately inversely proportional to the viscosity number (Saybolt Universal) of the oil at the existing temperature.

In conclusion it is well to point out the importance of designing wick-feed cups wide and shallow, thereby insuring a more uniform rate of oil feed. For an example, for an oiler in which the drop in the oil level is 2 in. between fillings, the feed when full is six and a half times greater than when the oil level is 2 in. lower. Hence, if the feed is correct at the low level, it is six and a half times too much when the oiler is full. This, of course, results in a large waste of oil.

A Question About Impact

A. B. Asch
Filtration Equipment Corporation

On page 9 of your January number, there appeared an article by David B. Turcott on "Bearings for Spindles Transmitting Impact Loads."

On Page 11 is given a formula

$$F_{max} = \frac{\pi F}{2 n r}$$

Where $F = \frac{33000\ hp.}{\pi D S}$ as set forth on page 10.

D = diameter of cutter
n = number of knives
S = r.p.m.
r = a ratio

The author then shows that F_{max} is ten times greater than F. But were this so the 20 *hp.* which he uses to arrive at F would actually require a motor capable of supplying 10×20 *hp.* at the peak. Or else, an enormously large flywheel.

The value r which gives this large result for F_{max} is used by the author in an attempt to allow for impact. I believe his method is open to question.

Also, on Page 11, he shows that a larger cutter will give a larger F_{max} for the same power consumed, because r is less. Here he is wrong because he again uses 20 *hp.* and calls F 120 lb. Actually F average will now be 60 lb., since the diameter of cutting circle is now twice as large. From this error the writer draws the conclusion that "For the same horsepower and with other conditions remaining the same, the maximum tangential force is greater for a larger cutting circle."

I would appreciate an expression of opinion on this subject from other readers.

Oil Film Pressures

James A. Hall
Professor of Mechanical Engineering, Brown University

Some of my friends have made some criticism of Professor Bradford's article on page 150 in the April number. The criticism centers around Fig. 3 where the velocity of the oil in different sections of the film at inlet and outlet are represented by straight line variations. I am not prepared to say that Professor Bradford's statement is incorrect but the inference read into it by some of the readers certainly is incorrect.

In the description under Fig. 3, if the statement had been made that the areas of the triangles represented the volumes of oil which would be drawn into the space and discharged if pressure was not built up in the film, and that the building up of the pressure tends to depress the hypotenuse of the right triangle at entrance and bulge it at exit, this might give a simple explanation of the theory back of building up pressure, which is generally demonstrated by means of some rather complex mathematics.

A Further Explanation

Louis J. Bradford
Professor of Machine Design
The Pennsylvania State College

Professor Hall's statement that Fig. 3 in my article on "The Effect of Fitting on Plain Bearing Performance," appearing in the April number of *Product Engineering,* does not represent the actual distribution of velocity in the oil film is entirely correct. The figure represents merely the velocity due to viscous drag alone, and this was pointed out both in the caption and in the text. For this it is correct. The object sought was to illustrate as simply as possible why a pressure was built up in a film, and to draw attention to the fact that a channel convergent in the direction of motion was necessary if a load was to be carried by the bearing.

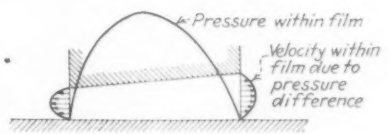


Fig. 1—Pressure differences cause a parabolic distribution in the velocity of flow in the film

Flow in the film separating journal and bearing is due to two causes. First, viscous drag, which produces a velocity distribution as shown in Fig. 3 of the article in question. Second, pressure differences, which give a parabolic distribution as shown diagramatically in Fig. 1 accompanying this article. The actual resultant velocity at any point in the film is the algebraic sum of velocities resulting at that point from these causes. Fig. 2 shows diagrammatically this distribution at entrance, exit and at the point of maximum pressure, for the set up used in Fig. 3 of the article.

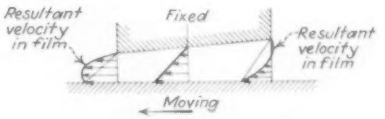


Fig. 2—Actual resultant velocity is the algebraic sum of the velocities resulting from viscous drag alone and from pressure differences

Better Drawings Needed

H. A. Pearson

Recent discussion about improved drafting room practice and more especially methods for specifying various machine finishes on shop prints prompts me to offer a plan in successful operation in a large plant since 1922. The first step was to establish standard sheets and to limit each sheet to a detail of one part. Bills of material were made on separate sheets and bound into a folder. Typical assembly tracings only were made.

In order to use standard-width tracing paper or cloth without waste from cutting, four sheet sizes were adopted, namely 24x36, 24x18, 12x18 and 12x9, all sheets to have $\frac{1}{4}$ in. margin on all four edges. These sheets sizes were designated by "A," "B," "C," and "D" and the drawing number was prefixed by this letter.

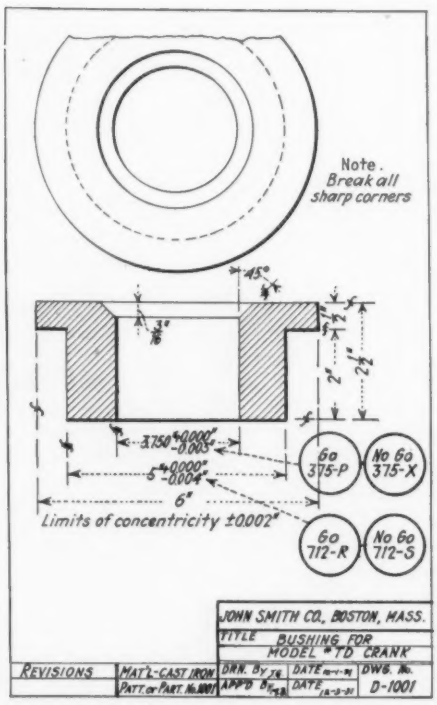
All tracing paper and cloth was bought cut to size with border lines, firm name and title form printed on

the reverse side so that erasures could be made. Prints as issued to the shop were shellacked on composition board and the surface of the blue coated with a clear shellac.

The next step was to work out a means of designating the machine finish required so that the designer got just what was required, the estimater something tangible upon which to base estimates, the shop and the inspection department something to form a basis for finish and workmanship.

Working samples were made for turning, planing, shaping and milling showing a rough, medium and fine finish as agreed to by the design, manufacturing, and inspection departments. These samples were coated with clear lacquer and placed conveniently throughout the shop. It was decided to designate the three degrees of finish by adding horizontal bars to the usual finish mark. This designation was put on the detail drawing and called "one-bar finish," and so on.

All decimal tolerances were shown on each detail, and in addition the



Typical detail drawing illustrating completeness of dimensioning, and notations

following note was printed on each sheet: "Unless otherwise specified all tolerances to be $\pm\frac{1}{64}$ in." All gage numbers were placed on each detail, and were circumscribed with a circle placed near the dimension to be gaged. The accompanying sketch illustrates a typical detail showing the completeness of a finished drawing.

Capacity of Clutches and Brakes

H. Copleston, *Staff Engineer,* and J. W. Hemphill, Jr., *General Power Products Department,*
Sales Engineering Department,
Johns-Manville Company

The articles on clutches and brakes, by A. C. Rasmussen, which have appeared in past numbers of *Product Engineering,* should be of interest to engineers as the author has shrewdly selected for the major topic of his discussion the real governing factor in the success or failure of clutch or brake design. In order to simplify calculations, the author introduced this controlling factor in the basic formula and factored so as to be able to substitute the variable and controlling values in an easy manner.

However, since the success of any brake or clutch is dependent to a great extent upon the maximum temperature of normal operation, and since the author endeavors to control this by limiting the rate of absorption per unit of area, unless the proper rate of absorption is selected for the particular conditions which obtain, a brake or clutch determined by this formula may fail because of high temperature.

The value of M as selected by the author, when considered as the foot-pound absorption rate per unit of area per minute is as follows:

M=0.25 to 0.40 hp.=8,250 to 13,200 ft.lb. per min.

M=0.20 to 0.30 hp.=6,600 to 9,900 ft.lb. per min.

Although these figures are correct for the specific type of service discussed by the author, in general, for severe service 1000 ft.lb. absorption rate per unit of area per minute has been considered conservative. For severe conditions one large industrial company has determined from experience that heavy equipment requires a 750 ft.lb. rate, and for the same service but a smaller machine, 1,200 can be safely employed. In consequence, the author's method will be quite successful, but the proper values of M must be selected.

The immediate heat generated by any clutching or braking action is for the most part absorbed by conduction of the heat through the metal. The ultimate drum temperature for any given number of engagements is dependent upon the mass of metal. The rate of heat dissipation from the drum is a factor of convecting surfaces. We, therefore, feel that before brakes and clutches can be designed to insure successful operation, factors such as metal mass of brake drum, convecting surfaces, kind of friction surface, ultimate temperature limit of the friction material and the number of engagements in a unit of time must be considered. We appreciate the difficulty in attempting to evaluate these factors.

We have checked an internal expanding band type clutch built by an equipment manufacturer with the following results:

$$\text{Ft.-lb. energy per min.} = \frac{\pi D N (T_1 - T_2)}{12} = 2{,}895{,}580 \text{ ft.lb.}$$

Area of lining = 365 sq.in.

$$\text{Ft.-lb. per sq.in. band area per min.} = \frac{2{,}895{,}580}{365} = 7{,}933 \text{ ft.-lb.}$$

$$\frac{7{,}933}{33{,}000} = 0.24 \text{ hp. per sq.in. band area}$$

The above figures check very closely with the horsepower factor set up by Mr. Rasmussen. It would be very elucidating to have the various equipment manufacturers check their band type clutches and brakes which are in operation to see how closely they come to the horsepower factors set up by Mr. Rasmussen. If this information could be collected for a symposium, it would be of great value.

The maximum pressure of engagement, as fixed by the author, is also recognized as a limiting factor in the success of a brake or clutch and its use appears to insure the success of the design as determined by the developed formula. Here again, success will depend upon the values assumed for the maximum pressures.

The section on rivets is well handled. Friction material manufacturers, however, generally recommend brass rivets. While some aluminum rivets do score quite readily and are not considered a satisfactory fastening, which is due to the inclusion of copper in the particular aluminum alloy, it is believed that a suitable aluminum alloy can be developed, if the subject were studied sufficiently.

In general, the author has handled

the subject well. The article should arouse considerable interest in the readers of the publication as the subject is one of importance, with many and very diverse ramifications.

In Answer to the Above

A. C. RASMUSSEN

Mr. J. W. Hemphill, Jr. refers to the many variables which are vital factors in the successful designing of friction clutches and brakes.

For revolving excavators of the shovel type, these factors were evaluated in the value for *M* given in the article in the December number of *Product Engineering*. However, the duty cycle will vary considerably from the excavator duty cycle for the many other kinds of service under which such friction devices must operate. The analysis to be presented in a forthcoming article in *Product Engineering* may be of some help in the solution of these problems.

The writer is endeavoring to collect all available data on clutch and brake installations. This data will be analyzed and compiled, and it is hoped that *Product Engineering* will publish the data when it is completed.

In answer to Mr. H. Copleston, with reference to the severe service conditions spoken of in his letter, it would be quite interesting to determine for each of these cases the horsepower per sq.in. *M* and the load factor *q*, which is the portion of the time that the clutch is in continuous use. Likewise, an analysis of the temperature rise calculations might explain why these units have such a low energy absorption.

In the next article (*which will appear in the June number*) *N* is mentioned as the continuous duty horsepower capacity per sq.in. of friction surface. This value probably is not constant for varying load factors. Also, it probably is larger for more frequent shorter applications than for less frequent but longer applications, the load factor being equal in the two cases. In the near future tests will be made to determine these relationships.

[Editor's Note—*In the June number Mr. Rasmussen will discuss the relation between heat-dissipating area and friction area. We also indorse the above suggestion for a "symposium" on the horsepower factors used by various equipment manufacturers and invite readers to forward to Mr. A. C. Rasmussen, or the editors, data on clutch or brake installations for publication in Product Engineering. Undoubtedly such a compilation will be of great value to the many engineers concerned with such designs.*]

Are Such Motors Available?

J. A. COVINGTON

One of my many friends, chief engineer of a laundry machinery company, asked me to suggest names of electric motor manufacturers who could supply him with motors having a 3 to 1 speed reducer built-in, and so designed that by the throw of a lever he could drive his machine either directly off the armature shaft or through the speed reducer. Now one would imagine that such a motor could be purchased from almost any of the many manufacturers, but inquiries directed to about half a dozen of them revealed that although 3- and 4-speed built-in reducers are relatively common, the 2-speed unit is apparently non-existent.

It seems to me that there should be a far greater field for 2-speed units than any other similar type. Laundry washers is but one example of where two speeds are required. Most printing and textile machines require two speeds, and this also holds true for many special machines. It seems almost inconceivable that the 2-speed mechanical speed change motor has been entirely neglected. Perhaps some of our progressive motor manufacturers can explain why such motors are not available.

DEFLECTIONS

BEWARE TRAMP IRON

The American Foundrymen's Association points out that scrap bronze has no part in the making of bronze bearings. All too frequently the scrap contains traces of iron. The Bureau of Standards has found that when the iron exceeds 3 per cent the grain size is reduced, the bronze is hardened, and segregation of the lead particles occurs.

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ONE SIGN

Prominently displayed in the assembly department of an automobile builder may be seen the following sign:

ATTENTION ALL DRIVERS
FREE WHEELING MUST BE
DISENGAGED ON ALL CARS
DRIVEN ON FACTORY PREMISES

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FIRST?

As nearly as can be determined the term "product engineering," not the name of this magazine, dates back some 20 years. At that time, a group of engineers of the Crane Company who had formerly been known as "mechanical experts" decided to invent a new name for themselves. They adopted the term "product engineer" as being truly definite of their function and have continued to use it until this day. Outside their buildings hangs a sign "Product Engineering." If there be other claimants for the honor of being the first product engineers to wear that title their claims will be given respectful consideration in this column.

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COTTONSEED GASOLINE

Although we are assured that American petroleum reserves will be good for at least another thousand years, some of us will be relieved to learn that good gasoline can be produced from ordinary cottonseed oil at a cost of $0.35 to $0.40 per gal. Dr. Gustav Egloff described to the American Chemicals Society how he runs the oil through a metal coil at a temperature of 900 deg. F. and a pressure of 150 lb. per sq.in. to break down the atoms and rearrange them. First comes gasoline; next emerges a heavy fuel suitable for diesel engines; next a coke and then some thirteen gases; lastly water, the only waste product.

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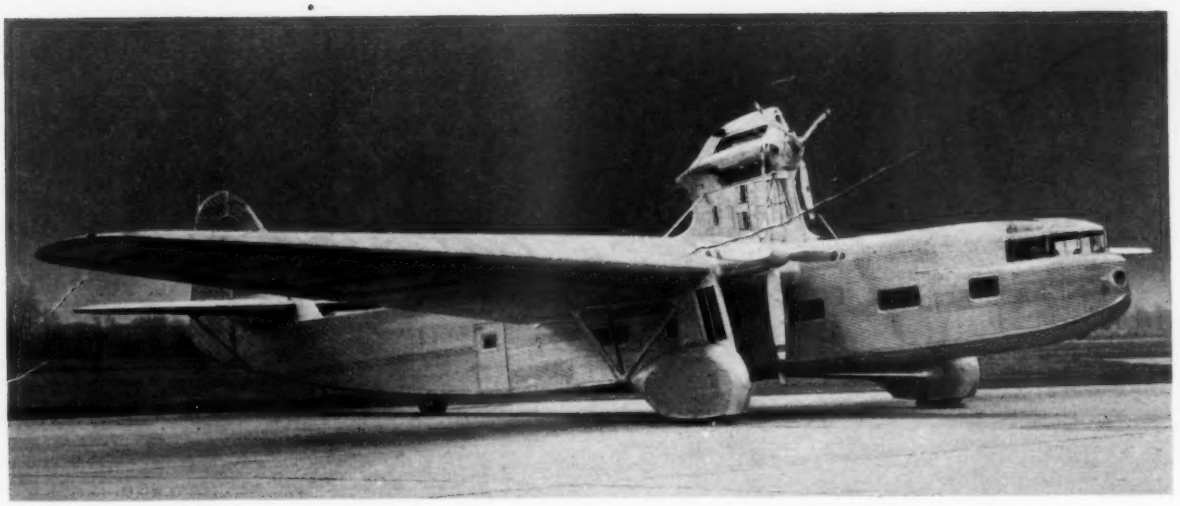
LICKING AN OLD PROBLEM

A Westinghouse research engineer has solved the problem of uneven wear and pitting of carbon blocks or brushes on rotating electrical equipment by cutting spiral grooves in the collector rings or the commutator. Although the area of contact is reduced almost 50 per cent, the life of the brushes is greatly increased.



110-ft. wing span, 80 ft. from nose to tail, this Ford Model 14-A was not exhibited at the Aircraft Show. Power plant consists of three units: one 1100-hp. "W" type Hispano-Suisa mounted over center section and two 720-hp. Hispanos mounted in the wings. Wing area, with ailerons, 1,600 sq.ft. Passenger capacity 32 day, 16 night

Second National Aircraft Show

Airplanes, Autogiros and Accessories All Show the Trend Toward Simplification, Safety, Less Expensive Maintenance, Greater Saleability

Engineers who supervised the designing of the airplanes exhibited at the Second National Aircraft Show, Detroit City Airport, April 2-10, seem to have had certain common aims in mind: easier, less expensive miantenance; passenger comfort and convenience; landing gear simplification and clean-up; visibility for the pilot. With the aerodynamics of the art fairly mastered and, to a great degree, standardized, they were able to turn their attention to a genuine refinement of their products. Saleability may be said to have been added to flyability.

Engines ranged from 2-cylinder opposed types to the 14-cylinder, double-row, 625 hp. 830-lb. Pratt and Whitney radial. Diesels were represented by Packard and Guiberson. Jacobs showed an engine "speed ring" with slots so placed that valve rods can be adjusted without removing the ring. The same maker also provided means whereby complete magneto assemblies and pump assemblies may be removed by the simple unscrewing of four bolts. Practically all engines were rubber mounted. After long test in actual flight, Timken was offering a tapered roller bearing for valve rocker arms. In the opinion of many observers, the showing of inverted cylinders-in-line engines was but a foretaste of designs now on the drafting boards. Pilots continue to demand utmost visibility.

With the exception of low wing planes, of which there were none, every conceivable arrangement could be found: from monoplanes and biplanes to gyros. Sikorsky showed the only amphibian. Waco was there with several models including a four-passenger cabin biplane, finished with all the luxury and comfort of a high grade motor car. Through sheer hard luck Ford disappointed the show visitors by being unable to exhibit the new 110-ft. wingspread aerial Pullman; the brake in one landing wheel seized, causing the plane to whirl around and to injure the tail wheel and the rear end of the fuselage. However, the two Ford planes that were exhibited caught one's attention through their unusual exterior and interior finish. One had been given a coating of copper bronze, the other of "buff silver bronze," with two coats of clear lacquer as an outercoat. A leather davenport was included in the interior furnishings of the former. Pitcairn Autogiro, which almost stole the show by its hovering performances in the air, featured a two-strut instead of the former three-strut rotor support. The designer of the Pilgrim transport plane had included ventilation through tubes running from slots in the leading edges of the wings, a single and accessible compartment for all electrical equipment just forward of the cabin, and a side-by-side two-place seat facing the regular single seats. Kellett showed a two-passenger cabin autogiro; Wilford Gyroplane showed only its new rotor with fixed but feathering blades. The only folding wing plane was represented by Nicholas Beazley, though one would consider the idea a fertile field for the designer intent on consumer preference.

Especially notable were the various conceptions of landing gears. Hydraulic shock struts held the stage, with but two rubber devices in evidence. In general there has been a thorough cleanup. And hardly a forward landing wheel could be found without its "pants." Bellanca, Stinson. Curtiss-Wright, Waco, Fairchild, Great Lakes and others can be cited for their good landing gear design.

Adjustable-pitch propellers created much comment, but hardly more than the new Curtiss one-piece Wyman-Gordon-forged prop, and the Dicks

hollow steel prop. Hamilton Standard showed an hydraulically operated variable pitch design; Smith showed a geared magnetically operated device with infinitely variable pitch settings; Bendix, a variable pitch prop controlled by the forward thrust of the plane; Curtiss, in addition to its one-piece job, a prop whose pitch is varied by electric motor.

New accessories and instruments were legion. Great Lakes had incorporated a stabilizer actuated from any position in the plane by means of a sash cord running to an irreversible screw. Breeze showed a braided aluminum alloy conduit so new that the Aluminum Company of America salesmen have not yet been given the number of the alloy used in the wire; also showed stainless steel flexible metal tubing in a variety of sizes. Pioneer Division of Bendix exhibited a deviameter so new that literature had not yet been prepared. It utilizes the principle of the horizontal gyroscope and can be reset for a changed course. Pioneer's new sensitive altimeter and alternating current tachometer were decided innovations.

Knitting Arts Exhibition

Many Exhibits and Some New Designs in Philadelphia April 11-15

As was to be expected, manufacturers of knitting machines and equipment have been putting their main effort in the development of new attachments and the refinement of existing designs. Although a few entirely new models were shown, in most of the exhibits the improvements pertained to details of design.

Standard-Trump Bros. Machine Co. had an entirely new machine in their "Standard 80 Wrap" hosiery knitter. In this individual needle wrap machine, the wrap cylinder is slotted so that the fingers can be arranged in the slots as desired, there being corresponding slots in the needle cylinder. In order to have the fingers more accessible for adjustment, the wrap finger cylinder can be swung up, pivoting about a hinge pin to the rear of the cylinder. Independent of this, the latch ring can be swung down, thereby giving clear access to the wrap fingers.

In the 25-step pattern control there are 96 moves on the trick or pattern wheel. The fingers operate continuously while the pattern is being knitted, but a finger wraps only when its corresponding needle is raised by the pattern control.

Collins Loom Works had a new model tricot machine which they call their "Super Marvel." In all details of materials and mechanisms, this machine is identical with the previous model but it is of heavier construction throughout and closer machined fits resulting in 30 per cent greater production capacity and yet running substantially free of vibration as was evidenced by a glass of colored water resting on the frame.

The machine is equipped with a new automatic electric stop motion developed by the Kingsborough Silk Mills. A break in a thread releases a finger that closes an auxiliary low-voltage circuit which operates the motor switch. Drive from the motor is by a flat belt with an idler.

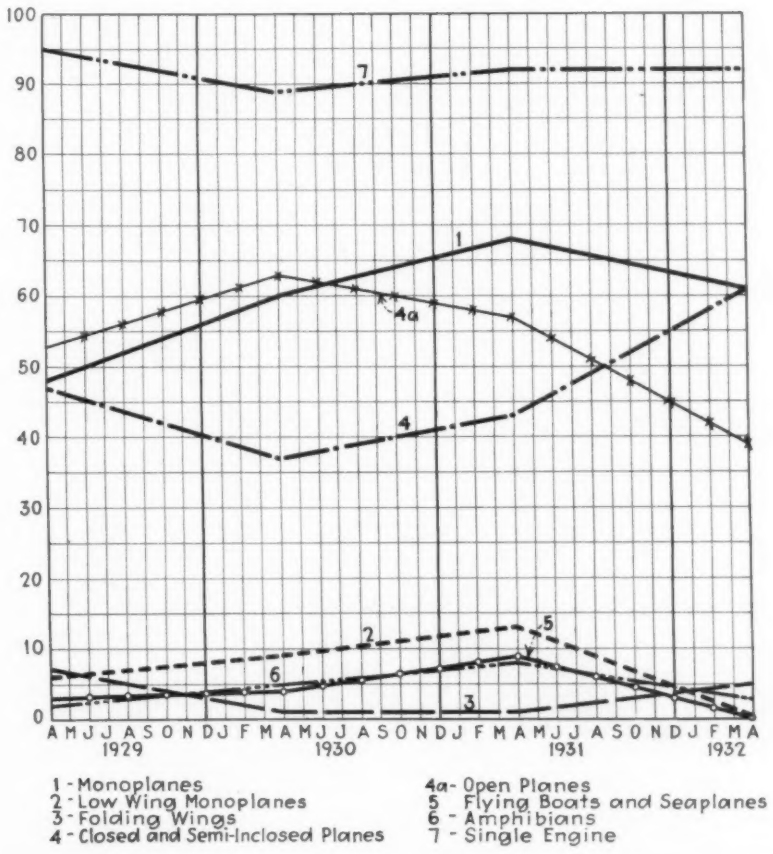
Proctor & Schwartz's new humidifier has many interesting points of design. It is an entirely self-contained unit. Air at 4 lb. per sq.in. is supplied by an unusual design of bellows-type pump mounted on a common base with a $\frac{1}{4}$-hp. motor, bevel-gear reduction drive, and fan. On the under side of the base is a partially filled tank of water, the level of which is maintained by a float valve. The air under pressure is furnished to this tank.

As the bellows-type pump does not require any lubrication whatsoever, the spray is therefore entirely free of oil. A feature of the design of this bellows-type pump is the mounting of the two 4-ply canvas diaphragms that make the bellows. The edges of the central hole in the diaphragms are riveted to a common steel ring, while the outer edges of the diaphragm are riveted to end plates. The inner surfaces of the end plates and both surfaces of the middle ring are so shaped that the diaphragms on the compression stroke are forced to bulge in such a manner that there will be no creases and material stresses will be at a minimum.

The $\frac{1}{4}$-hp. motor operates both the fan and the pump, the horizontal bellows being driven by the motor

Trends in Airplane Design

As Shown in Numbers Exhibited at Successive Aircraft Shows



through a worm reduction having a cam on the gear shaft that pushes a plunger on the compression stroke. The other end of the plunger bears against the end plate of the bellows. The return stroke is obtained by two helical springs, one on each side and equalized by being hooked to the end of a centrally pivoted lever.

The Smith-Drum Co. had on exhibition their new dyeing machine, constructed of Monel metal throughout. This skein dyeing machine has been improved by the addition of a Telechron motor control that can be adjusted for the desired length of dwell of the rotating carrier. Also, a solenoid brake is so arranged that when the machine is stopped the carriers will be stopped in their lowest position.

The General Electric Co. had on exhibit their "Turex" inspection pole, made of molded compound, taking the place of wooden poles that checked or splintered and the galvanized enamel pole that chipped.

A new double twister of the U. S. Textile Machine Co. was designed for higher production. On this machine gears have replaced all pulleys, idlers, and belts, including those on the spindle drive.

One throwing equipment manufacturer has added a new machine equipped with sliding motors for maintaining uniform tension on the belt. A new double-deck redraw machine is fitted with a slip starter to enable the spindles to pick up speed gradually. A new winding machine automatically controls the inspection of the worsted yarn. A knot or enlarged section of yarn automatically stops the machine with the imperfection directly in front of the operator.

Other interesting exhibits included a "universal" stitch machine capable of knitting plain mesh, figured mesh, and combination of mesh and float or mock wrap; a ribbed hosiery machine which employs all the dials and cylinder needles, and has been improved by the addition of a device for cutting the double sole and preventing the ends from knitting in; a 25-step spiral machine and other spiral machines for knitting color-within-a-color clocks; an improved circular outerwear machine, a new looper for joining the tops to the legs of the half hose and golf hose; and some new processing equipment.

▼ ▼

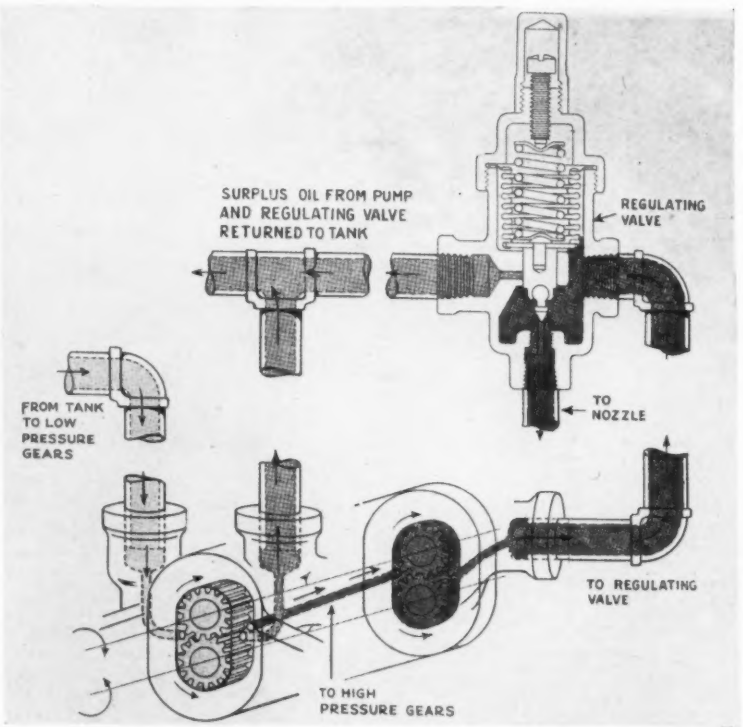
Ninth Annual Oil Burner Show

This review of the show, held in Boston, April 11-15, does not attempt to discuss all improvements because they are legion, but is confined to reporting certain principles found in some of the "high spots," the most recent developments and trends

Envious eyes are turned toward the oil heating industry because of phenomenal success during the last two years. Some may overlook the fact that before success can be achieved a great deal of concrete preparation must be gone through. To develop and sustain the very real and growing consumer demand, the industry has spent a great deal on research and design, and is maintaining this activity. It is true that design principles of the two common types of oil burners, gun and spinner, are well established. But many refinements are being made, especially in appearance, reliability and quietness. Since the burners are made up largely of purchased parts, it is natural to find the bulk of design activity among the various parts and accessory suppliers.

One recent tendency is to design a burner and boiler as a unit. In the "Electrol Richardson" a horizontal steel fire-tube boiler has the fire tubes arranged about a long central tube which is 12-in. O.D. This tube forms a combustion chamber somewhat similar to a Scotch marine boiler. The outer shell is placed eccentric with the boiler to form a preheating feedwater jacket and steam space. Much quicker steaming is accomplished because of the large ratio of heating surface to water carried in the boiler. Induced draft is accomplished by placing a blower in the flue at the rear. The blower motor also drives the fuel pump. The unit has a rectangular steel casing treated on the inside with acoustical material. Cool air entering the combustion chamber first passes over the motor and mechanism to keep them cool.

In oil burners the principles of operation are well established. Refinements are directed toward better appearance, quietness, reliable control and ease of servicing. To achieve greater quietness the "Bettendorf" burner now uses V-belt drive instead of direct drive. On the "Carter-Korth" a micrometer draft adjust-


SURPLUS OIL FROM PUMP AND REGULATING VALVE RETURNED TO TANK
REGULATING VALVE
TO NOZZLE
FROM TANK TO LOW PRESSURE GEARS
TO REGULATING VALVE
TO HIGH PRESSURE GEARS

To get constant pressure on delivery side of 2-stage pump, the low pressure side delivers excess quantity, the surplus returning to reservoir

ment is provided. Alignment between pump and motor is secured by machining a pilot in the motor end-bell and slipping the pump shaft into the pilot hole. A tongue and groove on the shafts eliminates a coupling.

An unusual pumping principle is found in the two-stage pump exhibited by Webster Electric. The principle of this pump is that delivery from the high-pressure side shall be at constant pressure and of course at constant volume, despite suction conditions on the low-pressure side. This effect is achieved by pumping on the low side three times the required delivery on the high side, the excess going back to the reservoir. Another feature of this design is that it is self-priming. Another pump manufacturer is putting out an assembly consisting of pumps, high and low-pressure regulating valve, strainer, and vacuum and pressure gages. This assembly reduces joints and consequently leakage and also eliminates vibration. The vacuum gage is unusual, but indicates immediately to the burner owner or to the service man if unusual conditions exist in the suction line to the storage tank.

Among safety controls is the "Protectoglow" system, made by Minneapolis-Honeywell, which employs two devices. The Protectoglow is the flame terminal of the system, and is mounted on or near the burner, so that the electrode extends into the flame. It contains a special three-element non-filled tube that reacts to a minute current passing through the flame. The Glo-Relay converts the demand of the Protectoglow and thermostat or control switch into relay action, thereby operating the valves or motor of the burner. The circuit is so arranged that when an electrical path is completed from the electrode to the ground, the Glo-Relay closes its contacts. In this case the circuit is completed when the flame is operating. The Glo-Relay actually incorporates two relays, the first starting the burner motor and supplying electric ignition. Heat is supplied to the safety switch at the same moment. The flame will impinge the electrode of the Protectoglow, closing the second relay which cuts off the ignition and heat to the thermal safety switch. The burner then continues in normal operation with the flame sustaining itself without ignition. Had the flame failed to ignite properly, it would not have impinged the electrode and the second relay would not have closed. The motor would have remained running with the ignition on until the expiration of the timing interval of the thermal safety switch. In case the flame should at any time fail to impinge the electrode during normal operation, the second relay immediately opens, returning the ignition and heat to the thermal safety switch. However, a safety shutdown would result here if the time limit should happen to be exceeded.

Meetings

A.F.A.

AMERICAN FOUNDRYMEN'S ASS'N.—36th annual convention, Hotel Statler, Detroit, May 2-5. C. E. Hoyt, secretary, 222 West Adams St., Chicago. The exposition has been cancelled.

A.G.M.A.

AMERICAN GEAR MANUFACTURERS ASS'N.—16th annual meeting, Hotel Statler, Cleveland, May 12-14. T. W. Owen, secretary, 3608 Euclid Ave., Cleveland, Ohio.

A.S.M.E.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS — Semi-annual meeting, Bigwin Inn, Lake of Bays, Ontario, June 27-July 1. Calvin W. Rice, secretary, 29 West 39th St., New York, N. Y.

M-M-M CONGRESS—Annual conference, Hotel Statler, Detroit, May 4-5. Papers of interest to product engineers include "Relative Wear of Metals by Abrasion," by C. R. Weiss, chief engineer of the Link Belt Co.; "Knowledge of Markets and Its Effect on Product Design," by Prof. R. F. Elder of Massachusetts Institute of Technology; and "Savings by Substitution of Other Metals," by George Bangs, Nassau Smelting & Refining Co.

Aeronautical Division, annual meeting, Buffalo, N. Y., June 6-8.

Applied Mechanics Division, annual meeting, Yale University, New Haven, Conn., June 23-25. J. M. Lessells, secretary, Westinghouse Electric & Mfg. Co., South Philadelphia, Pa.

A.S.T.M.

AMERICAN SOCIETY FOR TESTING MATERIALS—35th annual meeting. Chalfonte - Haddon Hall, Atlantic City, June 20-24. C. L. Warwick, secretary, 1315 Spruce St., Philadelphia. There will be included in the program a symposium on steel castings, jointly sponsored by the A.S.T.M. and the American Foundrymen's Ass'n. and a symposium on textile materials.

N.E.L.A.

NATIONAL ELECTRIC LIGHT ASS'N. 55th convention and exhibition, Atlantic City, N. J., June 5-10. Engineering sessions, June 7. A. Jackson Marshall, 420 Lexington Ave., New York, N. Y., is secretary.

N.M.T.B.A.

NATIONAL MACHINE TOOL BUILDERS ASS'N.— Machine Tool Exposition, scheduled originally for September, 1932, has been postponed to September, 1933. Aside from present business conditions, which were regarded as requiring increased emphasis on direct-selling efforts, members considered 1933 more favorable for other reasons, particularly the Chicago Fair in 1933, which will bring visitors from foreign countries.

S.A.E.

SOCIETY OF AUTOMOTIVE ENGINEERS —Summer meeting, White Sulphur Springs, W. Va., June 12-17. Chairman N. G. Shidle and other members of the Meetings Committee are preparing the program. Sessions are being arranged by the various professional activities, subjects to include standards, research and general topics. The latest developments in automotive engineering will be outlined, with discussions for and against the various points set forth by the authors.

INTERNATIONAL PATENT EXPOSITION. Grand Central Palace, New York, N. Y., May 10-28. The purpose of this exposition is to bring inventors and inventions in contact with manufacturers. Herman Larson, above address, is managing director in charge of all activities.

Engineers and their Activities

R. M. Hazen

A. E. Larsen

John G. Lee

Edward P. Warner

Among those who presented papers at the S.A.E. meetings held concurrently with the National Aircraft Show in Detroit, April 5-7, were the following: R. M. HAZEN, assistant engineer, American Airplane & Engine Corp., presented a paper on the development of higher speed engines and the use of reduction gearing; A. E. LARSEN, chief engineer, Pitcairn Aircraft, Inc., gave a technical analysis of the modern Autogiro; JOHN G. LEE, project engineer, American Airplane & Engine Corp., presented a discussion on maintenance of air transports as the designer sees it; D. L. PELLETT, of the University of Cincinnati, discussed "Photoelasticity and Its Application to the Study of Indeterminate Truss Stresses;" PROF. E. S. TAYLOR, of Massachusetts Institute of Technology, presented a paper on balancing four-cylinder aircraft engines. At the Thursday morning session, EDWARD P. WARNER, editor of *Aviation*, read his paper, "Rational Specifications of Load Factors."

ERIC G. ALMQUIST has received an appointment as a designer in the power-plant section, General Motors Corp. He was formerly with Packard Motor Car Co., Detroit, as a designer in the aircraft division.

PROF. GEORGE F. BATEMAN has been placed in charge of the schools of engineering of Cooper Union with the title of Acting Dean, replacing the late DEAN FRANCIS M. HARTMANN, according to a recent announcement by R. FULTON CUTTING, president of the Union Board of Trustees.

W. E. BLEWETT, JR., assistant to the president, Newport News Drydock & Shipbuilding Co., Newport News, Va., was a speaker at the April meeting, New York Chapter, A.S.S.T., Apr. 11. His talk covered the development of materials of suitable strength per lb. of weight, resistance to fatigue, weldability, ease of working and forming, and corrosion-resistance of power-house units under high temperature.

F. W. CURTIS, research engineer, Kearney & Trecker Co., Milwaukee, Wis., spoke on "Design of Machine Tools for High-Speed Use," at a meeting of the Chicago local sections, A.S.S.T. and A.S.M.E. April 14.

WALTER DE FRIES, who has recently been in charge of engineering of steel plate construction, modernizing designs of special steel metal equipment including hot metal handling, for the William B. Pollock Co., Youngstown, has become associated with the Pittsburgh Steel Foundry Corp., Glassport, Pa., in a like special engineering capacity. Prior to his identification with the Pollock company, Mr. De Fries served as assistant manager of the gas producer department of the Wellman-Seaver-Morgan Co., Cleveland, having come to this organization from the United Alloys Steel Corp., Canton, Ohio, where he served for some years as fuel engineer.

J. H. A. DOHSE has been appointed assistant superintendent of the plant of the Boeing Airplane Co., Seattle, Wash. Mr. Dohse, who was formerly production engineer in the engineering department, will perfect liaison between the engineering and production departments.

WILLIAM D. DRYSDALE is now chief engineer of Electric Devices, Buffalo, builder of household ice machines. He was formerly superintendent in charge of manufacturing and assembling for Whitehead Refrigeration Co., River Rouge, Mich.

O. E. ECKERT, previously connected with the Empire Refining Co., is now lubrication engineer with the Wilcox Oil & Gas Co., Tulsa, Okla.

EDWARD C. ELLIOT, president of Purdue University, will be the guest of honor at a formal invitational banquet, May 6, commemorating his ten years of service at Purdue and the sixty-third anniversary of the founding of the University.

E. S. ERICKSON has been elected vice-president in charge of engineering of the Mullins Manufacturing Corp. of Salem, Ohio.

SIR HENRY FOWLER, assistant to vice-president for research and development, Midland Railway Co., Derby, England, has been elected president of Institute of Metals, London.

ALFRED H. HOTOPP, JR., assistant engineer of Kolster Radio Corp. from 1928 to 1930, and later division engineer of Wired Radio, Inc., has been appointed engineer in charge of the receiver division, DeForrest Radio Co.

VICTOR KLIESRATH, chief of the automotive engineering division of Bendix Aviation Corp., was elected to the board of the company.

HOWARD F. KULAS, formerly vice-president and in charge of engineering and research at Midland Steel Products Co., Cleveland, has resigned.

CHARLES T. MAIN, consulting engineer, Boston, Mass., and past-president of American Society of Mechanical Engineers, has been given honorary membership by the Boston Society of Civil Engineers.

PROF. R. F. ELDER, assistant professor of marketing, Massachusetts Institute of Technology, will deliver a paper "Markets and Their Effect on Product Design" at the "M-M-M" Congress, A.S.M.E., Detroit, May 5.

F. HUGHES MOYER has been elected vice-president in charge of engineering for Mackintosh-Hemphill Co., Pittsburgh, succeeding W. L. DITGES. Before joining the company in 1926, Mr. Moyer was chief engineer of several steel plants.

G. F. NORDENHOLT, associate editor of *Product Engineering*, gave a talk, April 12, to the Renssellaer Student Branch of the A.S.M.E., on "Engineering the Product." In this address, illustrated with lantern slides, he analyzed recent outstanding designs, explaining how production economies were obtained, new materials adopted, and increased market value put into the product. The same lecture was given at Georgia Tech on April 19, and on April 26 was delivered to the mechanical engineering students at the Case School of Applied Science.

Prof. E. S. Taylor

Prof. R. F. Elder

G. F. Nordenholt

Norman N. Tilley

NORMAN N. TILLEY, formerly assistant engineer with American Airplane & Engine Corp., Farmingdale, N. Y., has been appointed chief design engineer of Continental Aircraft Engine Co., Detroit.

E. M. SCHULTHEIS, automotive engineer and technical service manager for the Timken Roller Bearing Co., has been transferred from Canton, Ohio, to the Detroit office.

HENRY W. SWEET, formerly chief engineer of Krohn Differential Corp., Buchanan, Mich., is now connected with Auburn Automobile Co., Auburn, Ind.

ERNEST L. THEARLE, research engineer, General Electric Co., will speak on "A New Type of Dynamic Balancing Machine" before the Applied Mechanics Division, Metropolitan section, A.S.M.E., April 26, 1932, in the Engineering Societies Bldg., 29 W. 39th St., New York City.

EDGAR L. VAIL, vice-president of the Jaeger Watch Co., Inc., New York, is on a visit to London, Paris and Switzerland with reference to the development of new designs of automobile clocks and mirror-clock combinations.

GERALD F. VULTEE, formerly chief engineer of Emsco Aircraft Corp., Downey, Calif., is now chief engineer of Airplane Development.

ROBERT T. WALKER, assistant to WILLIAM B. MAYO, chief engineer of Ford Motor Co., and for many years associated with the airplane division of that company, has resigned after 18 years with the company.

CORNELIUS P. WHALEN has established himself in New York City as a consulting engineer on special research engineering work. He was formerly vice-president of Minerva Automobiles, Inc., of New York City.

DR. WILLIAM E. WICKENDEN spoke recently on "The Economic Status of the Mechanical Engineer" before the Cleveland section of the A.S.M.E.

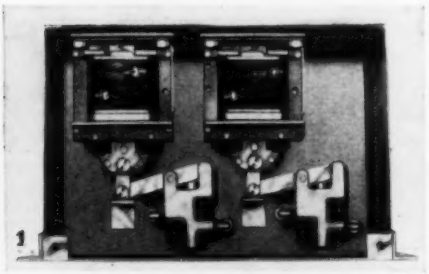
OTTO M. YETTER, who until recently was a junior experimental engineer with the Bijur Lubricating Corp., Long Island City, N. Y., is now motorcoach designer for A. M. WOLF, of New York City.

MATERIALS AND PARTS

Hannifin Electrically Operated Air Valves

The Hannifin Manufacturing Co., 621 S. Kolmar Ave., Chicago, announces three types of electrically operated air valves. Model C valve is furnished in both single and double types for remote control of either single-acting or double-acting air cylinders. It is especially valuable for the application of air cylinders to engage and disengage clutches on large machinery where it is desirable to enable the operator to control the machine from a number of stations. When the circuit is broken, the cylinder is open to exhaust.

Model D valve is designed for time-



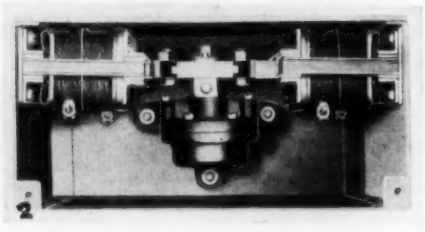


Fig. 1—Hannifin Model C valve for remote control of air cylinders. Fig. 2—Model E valve for 4-way control of double-acting air cylinders

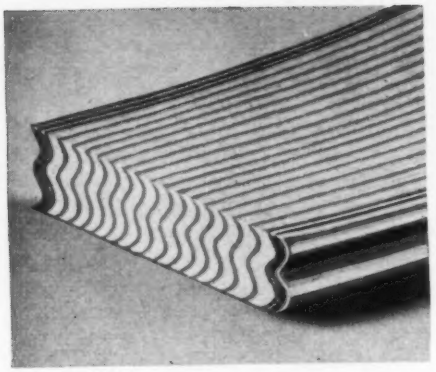
cycle operation or remote control of an air cylinder. It can be operated manually from a push-button station or automatically with an electrical time-cycle unit. Closing the circuit causes a pilot valve to admit air to a valve-operating cylinder which in turn operates a standard air control valve, controlling the power air cylinder. Being a single-acting, spring-return type, the valve-operating cylinder reverses the air-control valve when the circuit is broken, admitting air to the opposite side of the power air cylinder. Designed for applications where the power stroke is to be held for a short period, it is suited for operating cylinders of 8-in. bore and larger. It can be furnished with $\frac{1}{4}$, $\frac{1}{2}$, and $\frac{3}{4}$-in. operating valves.

Model E provides push-button control of 4-way valves controlling double-acting air cylinders, from one or more stations. Pressing the start button operates the cylinder in one direction and pressing the stop button reverses the cylinder, which is always under air pressure at one end or the other. This valve may also be arranged for automatic time-cycle operation by means of an automatic time switch. It is available in two sizes with $\frac{1}{4}$- or $\frac{1}{2}$-in. pipe connections. It incorporates the standard "packless" disk-type design employed by Hannifin.

All three types of valves are furnished for operation on a.c. or d.c. circuits, either 110 or 220 volt, except the Model D, which operates on 110-volt circuits only.

Garlock Guardian Gasket

Greater resilience is a feature of "Guardian" gasket, on which patents have been applied for by the Garlock Packing Co., Palmyra, N. Y. This type of gasket is offered for: safety against any pressure or temperature; resistance to gases and liquids; tight joints under changing conditions, and continued resiliency in service. The resilience of the gasket makes it applicable to pipe lines or equipment subject to vibration or rapid temperature fluctuations, and serves to make the gasket an expansion joint and thus



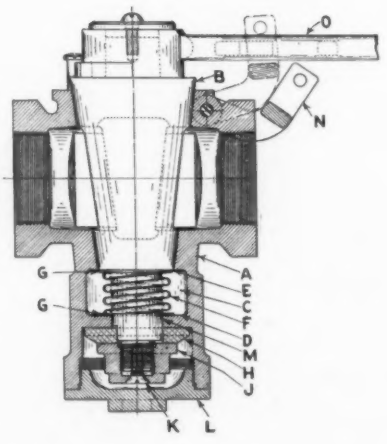
Cross-section of Garlock Guardian Gasket which consists of formed metal ribbon with asbestos interposed

eliminate leakage. As the illustration shows, the gasket is made by winding preformed metal ribbon with intervening layers of asbestos into a compact coil.

Swendeman Rotary Valve

A plug cock valve that does not stick or leak and does not require lubrication, it is claimed, has been developed by J. E. Swendeman, Inc., 171 Camden St., Boston, Mass. This "Rotary Valve" permits the plug to rotate in the seat.

The cross-section shows the valve structure, in which a tapered plug turns in a tapered seat. The valve casing *A* is provided with a spring chamber *C* with a shoulder or abutment at the outer chamber at *D* and a spring washer at the bottom of plug *B* at *E*. The spring *F* interposed between the abutment *D* and

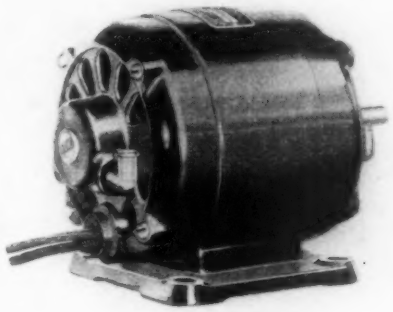


the plug base washer *E* counteracts binding action when turning the plug on its seat. *G* is a lower spring washer. The key collar *H* on the shank prevents adjusting nut *J* from

loosening. Safety screw-locking adjustment is at *K*. Other parts are housing cap *L*, plug shank *M*, operating lever locking device *N*, and operating lever *O*. It is evident from these details that the valve can be operated freely without lifting the plug from its seat.

Bodine Type N-3 Motor

The Bodine Electric Co., 2264 W. Ohio St., Chicago, Ill., has announced a small motor with wool-packed bearing. This Type N-3 motor is similar in design to the Type N-5, but is



rated at 1/20 and 1/15 hp. at 1,725 and 3,400 r.p.m. and at 1/30 and 1/20 hp., 1,125 r.p.m. Synchronous and split-phase induction motors and series and shunt d.c. motors are available in the same frame. A simplified automatic cutout is another feature. Large ventilating ducts are provided. Wool-packed bearings, designed to prevent flooding, are employed in this motor, which meets N.E.M.A. standards.

Bantam Full-Type Roller Bearings

A line of radial roller bearings having a full complement of rollers has been brought out by the Bantam Ball Bearing Co., South Bend, Ind., in standard ball-bearing metric sizes. These bearings have two lips on the inner rings or cone, and one lip on the outer ring or cup, with a detachable spring-steel locking lip on the other side. This construction allows the bearing to take a limited amount of thrust load in one direction.

Radial load capacity is said to be such as to make this bearing particularly adaptable to applications where the design will not lend itself to a larger bearing and where the necessary load capacity must be obtained in a limited space, such as on machine tools, electric motors, grinders, pumps and speed reducers. Tests indicate that this full-type roller bearing is quiet in operation at speeds up to 10,000 r.p.m.

High-carbon alloy steel is the material used for both the races and rollers. Size and run-out tolerances are the same as for a ball bearing of equivalent size and are according to S.A.E. specifications.

"Cellanite" Laminated Synthetic-Resin Sheets

Laminated synthetic-resin sheets, which do not incorporate the usual phenolic resin, are now being produced by the Continental-Diamond Fibre Co., Newark, Del. These "Cellanite" sheets are made by introducing the synthetic resin into the fibres before they are made into paper, which is laminated and compressed hydraulically under heat. The resultant product has high electrical and thermal insulating properties, great mechanical strength, is odorless and odor repelling, and is practically unaffected by water or oil. Furthermore, this material is not affected by alkaline solutions. Properties are as follows: Dielectric strength—800/900 volts per mil; power factor, 3; dielectric constant, 5.5; tensile strength ($\frac{1}{8}$-in. material) 12,000 to 15,000 lb. per sq.in.; transverse strength ($\frac{1}{8}$-in. material) 23,000 to 29,000 lb.; specific gravity, 1.35.

For the present, Cellanite is made only in sheets and in rods turned from sheets. Sheet sizes are 38x38, 38x43 and 30x38 in. Thicknesses range from $\frac{1}{32}$ to 4 in. Three grades are made as follows: Grade M—for mechanical, thermal and chemical applications. This grade is not used for electrical insulation, but has found use for breaker strips on refrigerator cabinets. It is odorless, odor repelling and immune to mold rot. Grade EX is for general electrical and radio insulation. Grade EXX is for electrical and radio insulation where extreme moisture resistance is imporant. Two colors are furnished; black and natural-brown to golden.

"Ke-Ci" Vacuum-Cap Pulleys

A metal pulley with vacuum cups spaced over the face has been placed on the market by the Keystone Engineering Co., Inc., 850 Maccabees Bldg., Detroit, Mich. As the belt reaches the cups the air in the cups is forced out and the atmospheric pressure against the belt holds it firmly against the pulley face to minimize

slip. The pulleys are available in sizes from 3 to 16 in. in diameter by 2 to 14 in. face.

"Nicral" Aluminum Alloys

Aluminum alloys containing nickel and chromium and known as "Nicral" are now being marketed by The Nicralumin Co., 146 W. Cortland St., Jackson, Mich., whereas until recently they were marketed by the Sheet Aluminum Corp., same city. In this system of alloys the Brinell hardness varies from 40 to 120, depending upon the grade and temper, and al-

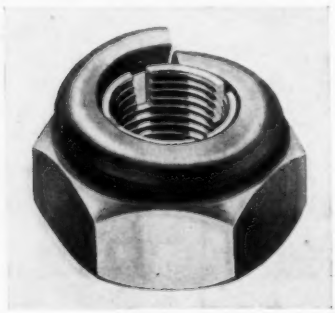
most any demand of hardness and strength can be met. Approximate composition of the alloys is given in the following table:

	NICRAL B	A	X
Ni	0.5	.1	1.0 per cent
Cr and related metals	0.25	.5	0.5 per cent
Cu	0.25	.5	1.0
Mg	0.25	.5	0.5
Fe & Si as in commercially pure aluminum			
Al	Remainder		

The color of Nicral resembles chromium plate, and this holds especially true for Nicral A. Nicral B in regard to color is not far removed that of pure aluminum. All grades keep a polished surface without excessive tarnishing. The alloys are suitable for drawing and forming, have good resistance to fatigue, are weldable, have high coefficients, of reflectively, retain strength at elevated temperatures and cast well. They are not subject to spontaneous aging. Weight per cu.in. is approximately 1 lb., and Youngs' modulus of elasticity is in excess of 10,000,000.

"Dalwa" Self-Locking Locknuts

More force is required to back off a "Dalwa" self-locking locknut from the locked position than is required to shear off a split cotter on the same size castle nut. This device is being marketed by the International Safety



Lock Nut Corp., 67 Broad St., New York, N. Y. The locknut is assembled into a single working unit—a nut proper, and an elastic steel compensator. The nut on the seating face is provided with a conical groove surrounding part of the threaded portion, which is divided into four equal segments by slots. The compensator is an elastic steel washer shaped to fit into the groove.

When the nut is drawn up, the compensator completely fills the conical groove in the nut, but at the start the included angle in the conical groove is smaller than the angle on the compensator. Thus, the four threaded segments are pressed into the thread on the bolt. It has been found by test that about 35 per cent of the thread of the nut is pressed against the stud by the compensator.

When the Dalwa nut is tightened down the following conditions are said to obtain: A greater axial clamping force is produced than with an ordinary nut; axial flexibility is obtained due to the special profile of the compensator; radial flexibility is produced, and any play arising from wear of the bolted components is automatically taken up by the axial flexibility of the compensator. The Dalwa nut can be produced in various materials where desired.

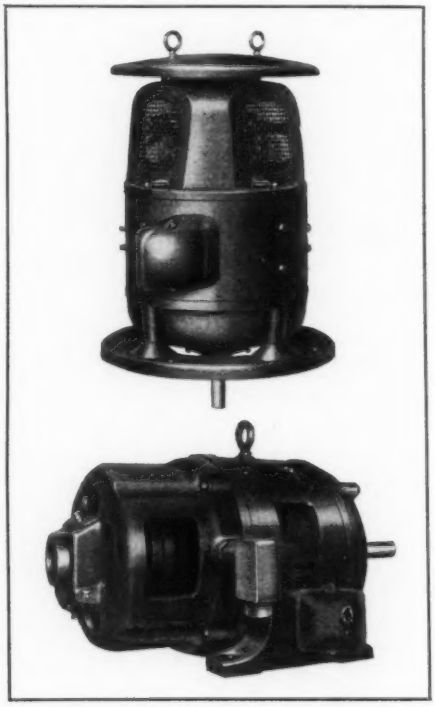
Vickers Balanced 4-Way Valves

Hydraulic balance in the 4-way control valves announced by Vickers, Inc., 7742 Dubois St., Detroit, Mich., is said to prevent binding of the valves due to pressure and to give sensitive operation. These compact valves are easily applied to machine tools or other hydraulically operated equipment, and are used for operating pressures up to 2,000 lb. per sq.in.

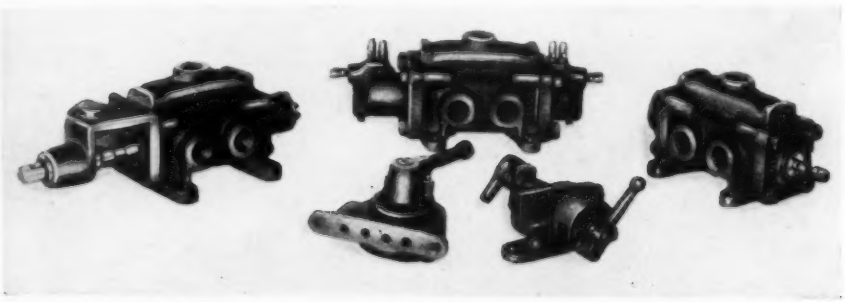
Of the three types of 4-way valves shown, the one at the left is a latch-controlled valve which makes one complete cycle and then stops. This valve is adapted to press operations and hydraulically operated furnaces. The operator manually starts the machine in one direction. At the end of the stroke a stop trips the latch and allows an internal spring to shift the valve to the reverse position. When the end of return is reached, the machine is stopped by the valve. A pilot-operated 4-way valve with manual and mechanical pilot valves constitutes the center group. It provides remote control without the use of levers or linkages. It has simple external adjustments for controlling the reversing speed to eliminate shock on rapidly moving tables. The manually operated 4-way valves are at the right. Bulletin 31-4 gives complete details of these valves.

Century D.C. Vertical and Slip-Ring Motors

The Century Electric Co., St. Louis, Mo., has announced two motors. The first is a Type R d.c. motor for vertical operation. This



motor is ball-bearing equipped, grease-lubricated, and mounted on a ring base or directly on the driven equipment. A cover protects the top bearing bracket and may be furnished open, with a screen or solid to meet surrounding conditions. Sizes of the motor are from 1 to 150 hp.



The line of slip-ring motors has been extended from 20 to 250 hp., 1,800 r.p.m., 60 cycles. The complete line ranges from $\frac{1}{4}$ to 250 hp.

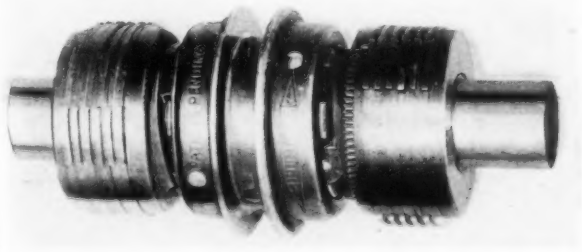
"National" Retaining Rings

Retaining rings are now being produced by The National Lock Washer Co., Newark, N. J., in standard stock sizes for shafts from $\frac{3}{16}$ to $1\frac{1}{2}$ in. in diameter. Each shaft size is made in three sections—light, medium and heavy—in round and square shapes, open and closed types. The retaining rings are heat-treated. Complete data are available in a catalog for engineering drafting room reference.

Morse Pullmore Clutches

The Morse Chain Co., Ithaca, N. Y., a division of the Borg-Warner Corp., has been appointed exclusive sales agent for Morse Pullmore clutches, manufactured by the Rockford Drilling Machine Co., Rockford, Ill., another division of the above corporation. This sales arrangement is made to avoid duplication of sales efforts, since the Morse industrial sales division specializes on power transmission units.

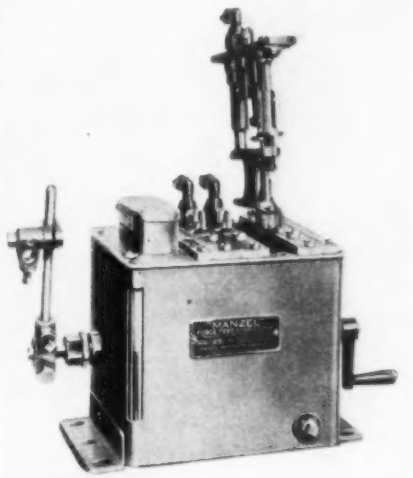
The Morse Pullmore clutch is a multiple disk friction drive unit made up in six standard sizes, single or double, from $\frac{7}{8}$ to $2\frac{1}{4}$ in. shaft diameters and from 2 to 25 hp. at 500 r.p.m. It is furnished either to operate in an oil bath or dry. The mechanism is alike in all clutches of the same size number, single or double, dry and oil type, and all parts are interchangeable. All parts except the outer disks in the dry type clutch are made from steel, hardened and ground where required. Bulletin C66 shows the construction of the Pullmore clutch and gives ratings.



Morse Pullmore Clutch which is made single or double in capacities from 2 to 25 hp. at 500 r.p.m.

Manzel Model 25 Force-Feed Lubricator

An independent oil line to each point to be lubricated is furnished by the automatic force-feed lubricator announced by the Manzel Brothers Co., 309-319 Babcock St., Buffalo, N. Y. This Model 25 lubricator is designed to be placed on the frame of the machine and connected to some movable part having either reciprocating or rotary motion. The lubricator incorporates a pumping unit for each feed line, and the feed is adjusted to the amount of oil required at each bearing. A sight feed shows the amount of oil being delivered by each.

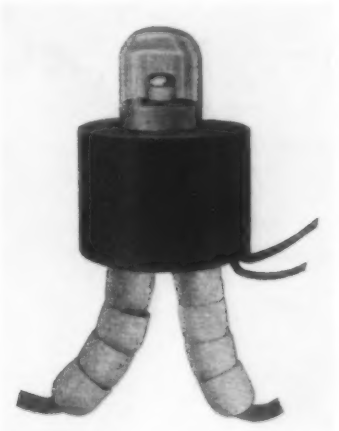


Manzel Model 25 Force-Feed Lubricator, showing the ease with which any unit may be removed

This lubricator can be furnished in many styles and with from one to 30 feeds, with either rotary or ratchet drive, and with different reservoir capacities. For high-speed machines requiring very small amounts of oil, lubricators with special reduced drives can be supplied, the reductions varying from $37\frac{1}{2}$ to 1 up to 3,600 to 1. For slow moving machinery direct-acting lubricators delivering oil at every stroke of the driving lever can be supplied to suit.

"Magnetrole" Mercury Switches

A full line of improved mercury switches, ranging in capacity from 1 to 100 amp., is being introduced by Providence Electric Controls Inc., 763 Allens Ave., Providence, R. I. In types having a rating up to 5 amp., special heat-resisting contacts are used. In the larger switches arcing takes place over a ceramic surface to eliminate danger of tube breakage.



"Magnetrole" 25-Amp., 250-Volt Mercury Switch

The "Magnetrole" mercury switch operates entirely by magnetic control. A gas-filled tube containing two mercury pools and a floating displacement member is placed within the field of an electrical coil. When the coil is energized the floating piece within the tube is drawn down to displace a certain amount of mercury. This causes a rise in the level of one of the mercury pools with consequent merging of contacts. The arc takes place around the edge of a treated ceramic tube which will withstand extremely high temperatures occurring during contact.

Allen-Bradley Four- and Five-Button Motor Control Stations

The line of Bulletin 800 push-button control stations manufactured by the Allen-Bradley Co., 1311 South First St., Milwaukee, Wis., has been expanded by the addition of 4-button and 5-button stations. The type N-1060 series of 4-button stations have three running buttons, giving three motor speeds, and one stop button. These buttons may be desig-

nated as: first—second—third—stop; slow—medium—high—stop; fast—slow—start—stop; 600-1,200-1,800-stop, or any other figures showing the three motor speeds. They are used extensively with automatic switches for three-speed motors of the squirrel-cage type.

The addition of a two-way lever switch to the above stations converts them into the type N-1090 series of 4-button stations. The two lever positions may read "off-on," "inch-run," or "safe-run."

The 5-button stations, known as the type N-1080 series, are for use with four-speed motors, giving four running speeds and stop.

New Books and Publications

ENGLISH-FRENCH DICTIONARY OF THE AUTOMOBILE AND ASSOCIATED INDUSTRIES. *By Lewis L. Sell, Ph.D. 768 pages, 5½x7½ in. Flexible clothboard covers. Published by the International Dictionary Co., 15 Park Row, New York, N. Y. Price, $6.*

Terms relating to the automobile and its component parts comprise many recent additions to the English and foreign languages. Consequently, there is much misuse of terms and many generalized applications of words which convey incorrect impressions. This difficulty is of course emphasized when translation is undertaken. Here then is a dictionary in two languages, listing some 150,000 terms relating to the automobile, its component parts, the machines used to make and repair it, even those for motoring and mechanical operation. Also included are the names and addresses of most automobile and accessory manufacturers, all in one comprehensive alphabetical listing. Exceptionally complete, this work should prove a useful addition to the library of the engineer having to do with automobile design, particularly for export.

MACHINE MADE LEISURE. *By Paul T. Frankl. 192 pages, 5x9 in. Clothboard covers. Indexed. Published by Harper & Brothers, Publishers, New York, N. Y., Price, $2.50.*

For light reading on a serious subject this book will be found interesting, but it does not do the author justice. Its title is also deceiving. It is one of a large number of books published recently on the general subject of product improvement by the application of art, but it does not appear that the author has any fixed object in view in the book. While a few specific cases are taken, most of the material consists of generalizations that are not particularly new. The book passes as one of inspiration rather than one of practical product engineering.

PHOTOELECTIC PHENOMENA. *By Profs. Arthur L. Hughes and Lee A. DuBridge. 531 pages, 6x9 in. Clothboard covers. Indexed. Published by the McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. Price, $5.*

Any engineer who is interested in the deeper problems of photoelectricity and has a grasp of higher mathematics will find this book a thorough and serious study of the subject. Experimental results having to do with the problems of emission of electrons from metals when illuminated are discussed, followed by theoretical problems. Photoelectric effects and practical applications are also treated. The volume is well illustrated with charts and diagrams.

THE ADVANCED TECHNIQUE OF PORCELAIN ENAMELING—*By J. E. Hansen, Research Engineer, Ferro Enamel Corporation. 312 pages, 5½x8¼ in. Indexed. Clothboard covers. Published for the Ferro Enamel Corporation by The Enamelist Publishing Company, Cleveland, Ohio. Price $3.50.*

Although written largely from the production point of view, there are several chapters of this book that are of interest to the engineer who wishes to understand porcelain enameling sufficiently well to specify it intelligently. The chapter on mill additions and color oxides is particularly valuable in summarizing the complex constituents of porcelain enamels and what the possibilities are as regards opacity and color. The chapter on decorative effects is another one that should be of interest to designing engineers and summarizes briefly all the processes.

ELECTRIC HEATING UNITS. The Edwin L. Wiegand Co., 7500 Thomas Blvd., Pittsburgh, Pa., has issued Bulletin C-113 entitled "Chromalox Electric Cartridge Units," showing types for both low and high capacity and illustrating installation and terminal construction. Dimensional data, specifications and prices of over 300 units are listed.

FINISHES. "Pre-Tested," a bulletin issued by E. I. DuPont de Nemours & Co., Parlin, N. J., and beautifully illustrated in color, tells how pre-testing in the manufacturer's plant assures results of its finishes upon products and plant equipment.

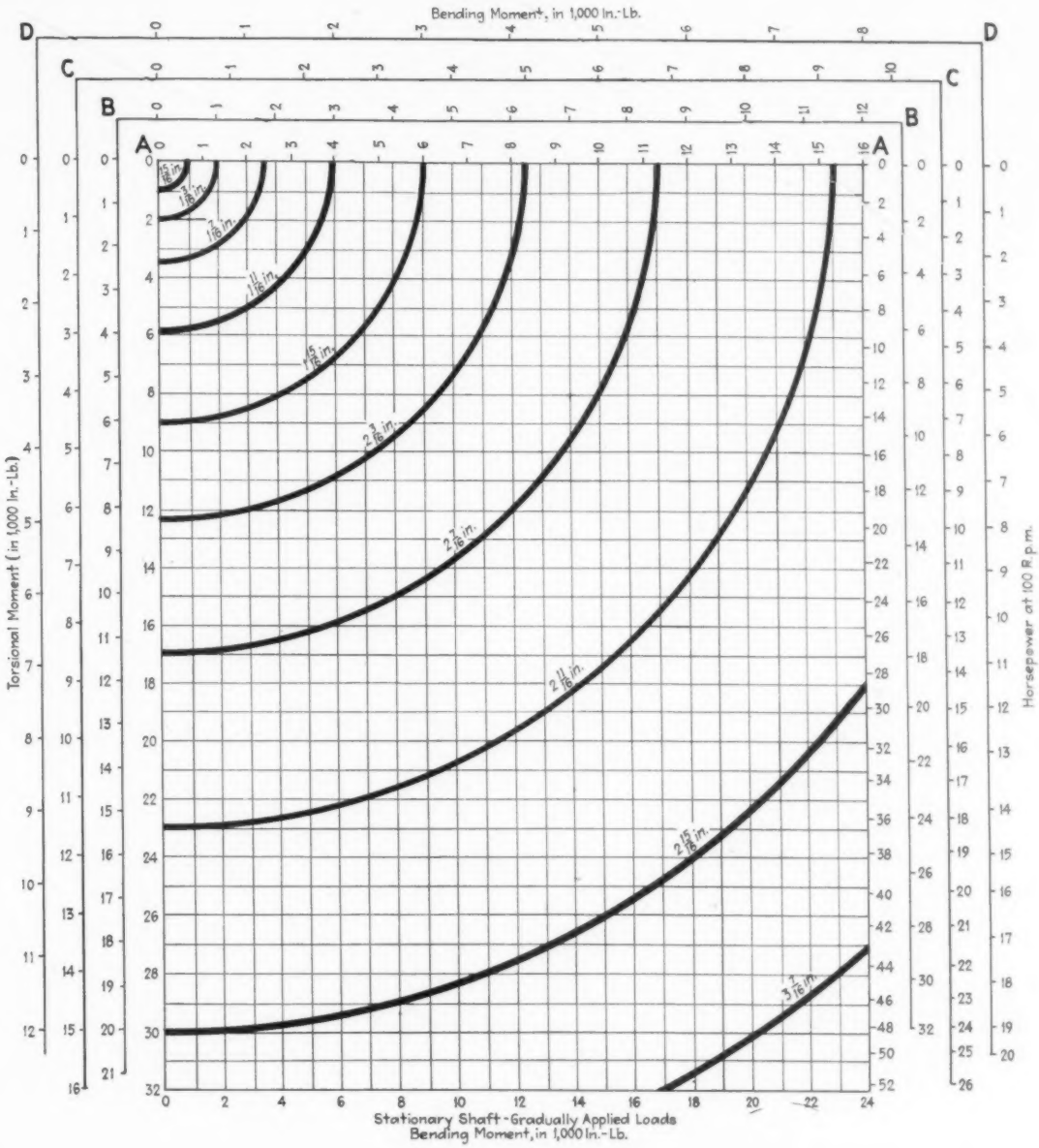
FLEXIBLE COUPLINGS. Diamond Chain & Mfg. Co., Indianapolis, Ind., has published Catalog No. 11 on construction features and ease of installation and disconnection of "Diamond couplings," illustrating and tabulating all types and sizes in the line.

ILLIUM. The Burgess-Parr Co., division of C. F. Burgess Laboratories, Inc., Moline, Ill., has prepared a bulletin describing some of the commercial applications of Illium, a complex alloy of nickel-chromium base. Test data compare resistance to corrosion with other alloys. Fabricating possibilities such as machining, welding, grinding or polishing are illustrated. The bulletin is attractively illustrated with a large number of photographs.

LAMINATED PHENOLIC PRODUCTS. A four-page engineering design folder, issued by the Spaulding Fibre Co., Inc., Tonawanda, N. Y., lists the mechanical, electrical and chemical properties of "Spauldite" laminated sheets, together with engineering information.

TESTING MACHINES. What constitutes a short textbook upon Southwark-Emery hydraulic testing machines has been published by the Baldwin-Southwark Corp., Philadelphia, Pa. The bulletin shows many horizontal and vertical testing machines, the latter ranging up to 4,000,000 lb. capacity.

PLYWOOD. Description of the product, physical characteristics, strength, finishing properties, standard sizes, standard grades, representative uses are listed in a folder "Facts about Douglas Fir Plywood" issued by the Douglas Fir Plywood Manufacturers, Skinner Bldg., Seattle, Wash.


Bending Moment, in 1,000 In.-Lb.
Torsional Moment (in 1,000 In.-Lb.)
Horsepower at 100 R.p.m.
Stationary Shaft - Gradually Applied Loads
Bending Moment, in 1,000 In.-Lb.

Shaft Diameters Based on the A.S.M.E. Code

SCALES (for Rotating Shafts)

A—Gradually applied loads
B—Suddenly applied loads, minor shocks
C—Suddenly applied loads, heavy shocks
D—Severe operating conditions—high reliability

Use of the Charts—Example:

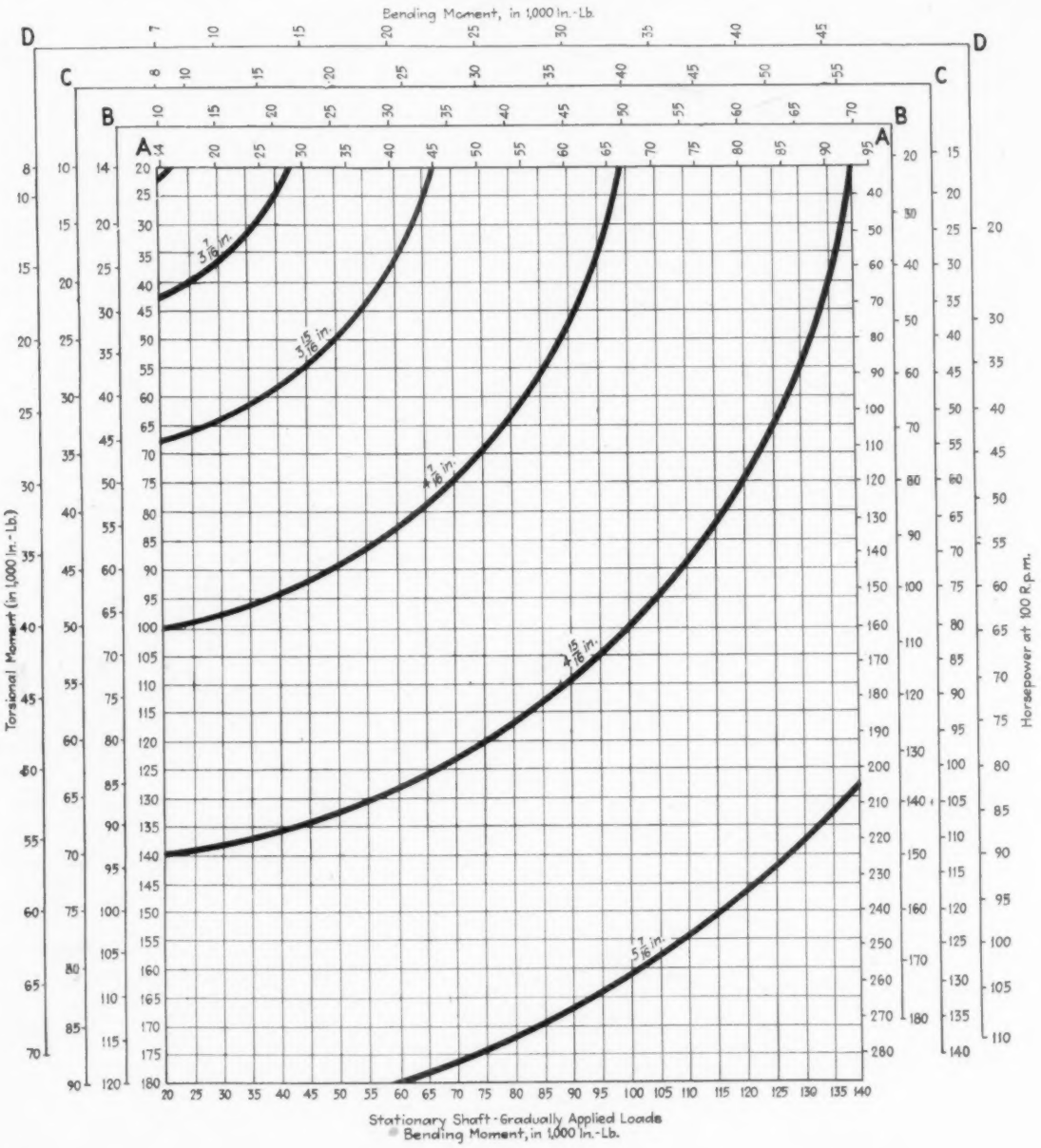
Consider a shaft transmitting a steady load of 25 hp. at 200 r.p.m. and subjected to a bending moment of 10,000 in.-lb. If the shaft is made of ordinary cold-drawn shafting used for power transmission work and has a keyway at the point where the bending moment is maximum, a working stress of 6,000 lb. per sq.in. should be used. To find the horsepower at 100 r.p.m. the following formula can be used:

$$Hp.\ at\ 100\ r.p.m. = \frac{hp.\ transmitted}{r.p.m.\ of\ shaft} \times 100$$

For this problem the hp. at 100 r.p.m. is 12.5. Trace across from 12.5 to 10,000 in.-lb. bending moment line for the scale for steady loads. The shafting size is found to be $2\frac{7}{16}$ in. If there were no keyways, a working stress of 8,000 lb. per sq.in. could be used. The factor for this stress is given as 0.909, and hence the diameter for this stress would be $2\frac{7}{16} \times 0.909 = 2.19$. Therefore a $2\frac{3}{16}$-in. shaft could be used if there were no keyway present.

The charts on this page and the one on the next page are to be used in conjunction with the article "Rational Design of Shafts" on page 207.

REFERENCE BOOK SHEET



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Other Values of S_s

In making the chart on this and the preceding page, the value of S_s was taken as 6,000 lb. per sq.in. For any other value of S_s multiply the shaft diameter by a factor from the following table.

S_s	Factor	S_s	Factor
1000	1.817	9000	0.874
2000	1.587	10000	0.843
3000	1.260	11000	0.817
4000	1.145	12000	0.794
5000	1.063	13000	0.773
6000	1.000	14000	0.754
7000	0.950	15000	0.737
8000	0.909	16000	0.721

Contributed by Emory N. Kemler
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